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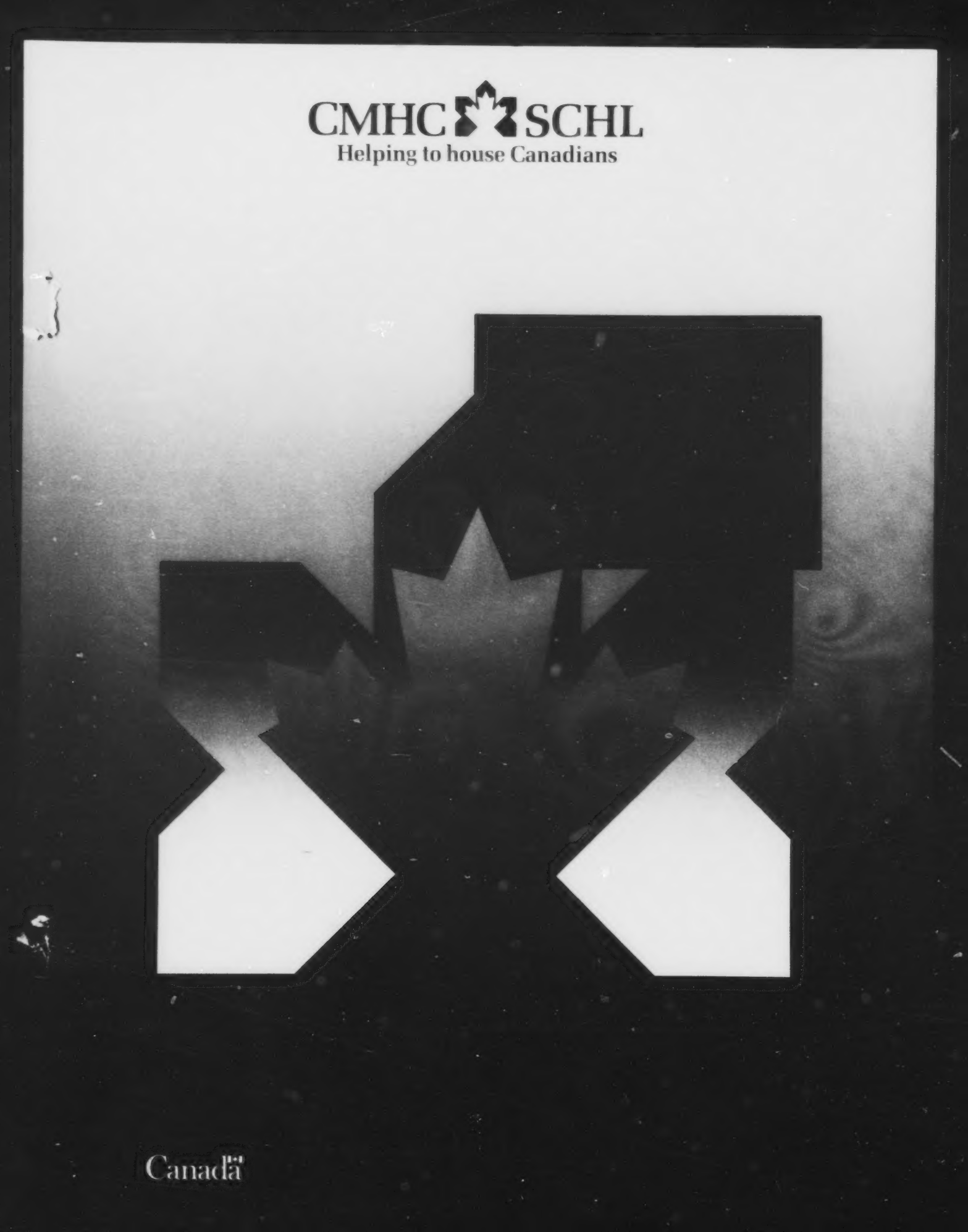

Canada

TESTING OF OLDER HOUSES FOR MICROBIOLOGICAL POLLUTANTS

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FINAL REPORT

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ABSTRACT

Field investigation of 28 homes in Tillsonburg, Ontario was undertaken in early 1991. The investigation concentrated on indoor air quality, and in particular, microbiological pollutants. Measurements of temperature and humidity, airborne fungal spores and bacteria were made in the living areas under natural conditions, and with the house depressurized to more than 20 pa, by means of a "fan-door" depressurization apparatus. Surface samples were obtained and analyzed for mould and bacterium. The relative airtightness and air-change rate of the houses was evaluated by depressurization testing and slow-release tracer gas testing. A physical evaluation of the building was done with an emphasis on aspects which would lead to higher levels of dampness and/or mould growth.

Fungal Spore levels of 3 to 950 cfu/m^3 were recorded in living areas and 19 to 4630 in basements. Bacterial levels of 106 to 3906 cfu/m^3 were recorded in living areas and 140 to 2875 in basements. 29 different fungal species were selected as predominant in individual houses and identified as to species. 10 of these species have been reported by other authors (6) as "Toxigenic" or "Mycotoxin-producing". House airtightness values of ELA_{10} 351 to 3437 cm^2 (NLA_{10} 1.03 to 7.91 cm^2/m^2) were measured. Air-change rates of 0.101 to 0.728 AC/h (15 to 161 l/s) were measured. Many construction features, equipment, appliances and operating modes were identified which contributed to higher levels of dampness, condensation and mould growth. The houses were ranked according to microbiological pollutant levels and the features and mechanisms leading to the higher levels of mould and bacterium were enumerated. Low air-change and exposed soil conditions were found to be frequent, but not universal or exclusive, mechanisms leading to higher levels of airborne mould and bacterium.

EXECUTIVE SUMMARY

Field investigation of 28 homes in Tillsonburg, Ontario was undertaken in early 1991 as a follow-up to a 1988 Health and Welfare Canada questionnaire study (Ref. 3), the results of which indicated a link between home dampness and poor respiratory health.

The investigation concentrated on indoor air quality, and in particular, airborne moulds and bacterium. Measurements of temperature and humidity, airborne fungal spores and bacteria were made in the living areas under natural conditions, and measurements of basement air fungal spores and bacteria were made with the house depressurized to more than 20 pa, by means of a "fan-door" depressurization apparatus. Surface samples were obtained and analyzed for mould and bacterium. Mould and bacterium samples were analyzed as to quantity (a count of the number of colonies) as well as to quality, by identification of the most prominent moulds and bacteria as to species. A depressurization test was performed to evaluate the relative airtightness of the house. A slow-release tracer gas test (PFT) was performed to evaluate the actual air-change rate of the structure over a minimum one-week period. A physical evaluation of the building was done by an experienced Building Technologist, with an emphasis on aspects which would lead to higher levels of dampness and/or mould growth.

Fungal Spore levels of 3 to 1200 cfu/m^3 were recorded in living areas and 70 to 4600 in basements. Bacterial levels of 150 to 4000 cfu/m^3 were recorded in living areas and 150 to 3000 in basements.

Analysis of the moulds selected as being prominent produced 29 different species from 56 samples. Of these 29 species, 10 have been identified by other authors (Ref 6) as "Toxigenic" or "Mycotoxin-producing". Analysis of the bacteria selected as predominant produced 25 different species from 47 samples.

House airtightness values of ELA_{10} 351 to 3437 cm^2 (NLA_{10} 1.03 to 7.91 cm^2/m^2) were measured. Air-change rates of 0.101 to 0.728 AC/h (15 to 161 l/s) were measured. 10 of the houses averaged less than 0.3 AC/h.

Many construction features, equipment, appliances and operating modes were identified which contributed to higher levels of dampness, condensation and mould growth. The houses were ranked according to microbiological pollutant levels and the features and mechanisms leading to the higher levels of mould and bacterium were enumerated. Mechanisms which were most often found to lead to high levels of mould and bacterium were found to be Low air-change and Exposed soil, although the existence of these mechanisms in a house did not necessarily lead to high mould and bacterium levels.

Analysis of construction features, equipment and appliances found that houses with central air conditioning and gas fuelled heating and hot water systems tended to not to have high airborne microbial levels. Houses with crawlspaces, electric or sealed combustion water heating, mouldy walls and mouldy smelling basements tended to have high levels of mould and bacterium. The number of plants in the house had little bearing on the level of

mould and bacterium, but tended to be found in houses with predominantly leaf-type moulds such as Cladosporium sp..

Occupants who operate their humidifiers more frequently and who set the space temperature back more often and for longer periods of time tended to have homes with higher levels of microbial activity. Occupants who kept their furnace filters in good condition had more mould and bacterium than those who had filters in poor condition. (Typical furnace filters are ineffective in removing fine particles until heavily loaded with dust.)

Furnace-mounted humidifiers were found to be less productive than expected for mould and bacterium, but portable drum-type humidifiers were found to be quite productive. Refrigerators were found to be productive sources if their design was such that the defrost drain tray was not heated by the condenser or compressor. Windows in general were found to be the most popular sources of moulds, and in particular bedroom windows. Basement surfaces and in particular cold-rooms and exposed soil were also found to be productive sites for mould and bacterium. Bath/shower enclosures usually produced productive samples of both mould and bacterium.

There was good agreement between the predicted air change rate using the fan-door test results and the tracer gas air-change tests (Figure 6) and there was a strong relationship between the air-change rate and the interior humidity level (Figure 15).

Indoor/outdoor airborne fungal spore density ratio was found to be more meaningful than indoor airborne fungal spore density levels, where moderate or low (below 200 cfu/m^3) densities are encountered. Low/moderate fungal spore levels may also not be meaningful if the outdoor and indoor samples are not analyzed at least to genus for the three most popular types of mould.

There were no particular relationships (other than on a case-specific basis) between airborne mould and bacterium and each other, or to air-change rate or humidity level.

Penicillium sp. were found to be the most popular indoor air fungi and Staphylococcus sp. and Micrococcus luteus the most popular bacterium. From surface samples, Cladosporium sp. was the most popular fungus and Pseudomonas sp. and Bacillus sp. were the more popular bacteria depending upon whether the site was wet or dry.

Fungal species which are accepted to have high toxic potential such as Aspergillus fumigatus and Stachybotrys atra were not identified, however this does not mean that they did not exist in some houses, rather they were not selected as the prominent species from the air and surface samples.

Detailed investigation showed that in one case, the cause of high indoor bacterium levels was directly attributable to the basement soil. In other instances, the conclusions are less positive, but would seem to indicate that, at particular mould producing sites, the second or third most predominant mould may be responsible for the highest airborne spore level. For this reason, it may be that meaningful results will only be obtained where both air and surface moulds are analyzed at least to genus for the three most popular types.

Analysis of the results for pathological or health implications is beyond the scope of this report.

RÉSUMÉ

Au début de 1991, à Tillsonburg, en Ontario, 28 maisons ont été analysées comme suite à une étude par questionnaire de Santé et Bien-être social Canada (réf. 3) qui établissait un lien entre l'humidité des habitations et les problèmes respiratoires.

L'analyse s'est limitée à la qualité de l'air intérieur et, en particulier, à la présence de moisissures et de bactéries aériennes. La température, l'humidité, les spores fongiques et les bactéries aériennes ont été mesurées dans les aires de séjour en conditions normales. On a aussi quantifié les spores fongiques et les bactéries aériennes présents au sous-sol après avoir dépressurisé la maison à plus de 20 Pa au moyen d'un ventilateur d'extraction aménagé dans une porte. Des échantillons de moisissures et de bactéries ont été recueillis sur les surfaces. Ces échantillons ont été analysés pour déterminer le nombre de colonies et connaître les espèces de moisissure les plus courantes. Un essai de dépressurisation a été mené afin d'évaluer l'étanchéité à l'air relative de la maison. De plus, on a réalisé un essai à gaz de traçage à libération prolongée (traceur au fluorocarbure) afin de connaître le taux de renouvellement d'air du bâtiment pendant au moins une semaine. Un technologue du bâtiment expérimenté a évalué les lieux en s'attardant sur les facteurs pouvant favoriser l'humidité ou la prolifération des moisissures.

Le technologue a relevé des concentrations de spores fongiques de 3 à 1 200 UFC/m^3 dans les aires de séjour et de 70 à 4 600 UFC/m^3 dans les sous-sols. Il a en outre enregistré des concentrations de bactéries de 150 à 4 000 UFC/m^3 dans les aires de séjour et de 150 à 3 000 UFC/m^3 dans les sous-sols.

L'analyse des moisissures les plus courantes a fait ressortir 29 espèces différentes parmi 56 échantillons. De ces 29 espèces, 10 sont considérées, par d'autres auteurs, comme toxicogènes ou productrices de mycotoxine (réf. 6). Quant à l'analyse des bactéries les plus courantes, 25 espèces différentes ont été identifiées parmi 47 échantillons.

L'étanchéité à l'air de la maison a été mesurée. La surface de fuite équivalente est de 351 à 3 437 cm^3 à 10 Pa (1,03 à 7,91 cm^2/m^2 à 10 Pa pour la surface de fuite normalisée) et les taux de renouvellement d'air sont de 0,101 à 0,728 (de 15 à 161 L/s). Dix des maisons étudiées ont un taux moyen inférieur à 0,3 renouvellement d'air par heure.

Le technologue a repéré un grand nombre d'éléments de construction, d'équipements, d'appareils et de modes d'exploitation qui favorisent l'humidité, la condensation et les moisissures. Les maisons ont été classées selon leurs taux de polluants microbiologiques, et les éléments et mécanismes occasionnant des taux élevés de moisissures et de bactéries relevés. Les plus fréquents sont le faible taux de renouvellement d'air et le sol nu, quoique ces facteurs n'entraînent pas nécessairement une prolifération des moisissures ou des bactéries dans la maison.

L'analyse des éléments de construction, des équipements et des appareils a fait ressortir que les maisons dotées d'une installation centrale de climatisation et d'un système de chauffage et de chauffe-eau au gaz présentent des concentrations moins élevées de microbes aériens. Les maisons avec vide sanitaire, celles qui sont pourvues de chauffe-eau électriques ou à combustion optimisée de même que celles dont les murs montrent des signes de moisissure ou dont le sous-sol sentent le moisi ont tendance à présenter des taux élevés de moisissures et de bactéries. Par ailleurs, le nombre de plantes dans la maison a peu d'effet sur les concentrations de moisissures et de bactéries. Il y a des plantes dans les maisons où l'on trouve surtout des moisissures s'attaquant aux feuilles comme *Cladosporium sp.*

Les occupants qui font fonctionner leur humidificateur régulièrement et qui abaissent souvent la température des pièces pendant d'assez longues périodes ont tendance à favoriser ainsi l'activité microbienne. Ceux qui entretiennent les filtres de leur générateur d'air chaud ont plus de problèmes de moisissures et de bactéries que les occupants dont les filtres sont en mauvais état (les filtres de générateur courants ne peuvent retenir les particules infimes que lorsqu'ils sont surchargés de poussière).

Les humidificateurs d'appareil de chauffage produisent moins de moisissures et de bactéries qu'on pourrait le croire, en comparaison avec les humidificateurs portatifs à tambour qui en produisent beaucoup. Les réfrigérateurs constituent aussi une source de prolifération microbienne lorsque le bac de dégivrage n'est pas chauffé par le condenseur ou le compresseur. En général, les fenêtres, surtout celles des chambres, sont les plus grandes sources de moisissures. Les surfaces des sous-sols, particulièrement les chambres froides et les endroits où le sol est dénudé, sont très propices à la prolifération microbienne. Les salles de douches ou de bains engendrent habituellement des échantillons productifs de moisissures et de bactéries.

Le taux de renouvellement d'air prévu à partir des résultats des essais de dépressurisation et des essais menés au gaz de traçage concordent très bien (Figure 6), et on a établi un lien certain entre le taux de renouvellement d'air et le taux d'humidité intérieure (Figure 15).

Le rapport de densité intérieure-extérieure des spores fongiques aériens s'est révélé plus significatif que les niveaux de densité intérieure des spores fongiques aériens puisque ceux-ci varient de modérés à faibles (c.-à-d. moins de 200 UFC/m^3). Des niveaux de spores fongiques modérés ou faibles peuvent également ne pas être significatifs si l'on ne détermine pas au moins le genre des échantillons pris à l'intérieur et à l'extérieur quant aux trois types de moisissure les plus courants.

On n'a constaté aucun autre lien particulier (sauf pour certains cas précis) entre les moisissures et les bactéries ou entre ces organismes et le taux de renouvellement d'air ou le taux d'humidité.

Penicillium sp. est la moisissure la plus souvent observée dans l'air des habitations tandis que *Staphylococcus sp.* et *Micrococcus luteus* sont les bactéries les plus courantes. Parmi les échantillons de surface, *Cladosporium sp.* est la moisissure la plus fréquente alors que *Pseudomonas sp.* et *Bacillus sp.* sont les bactéries les plus courantes selon que les lieux sont secs ou humides.

Les espèces de moisissure pouvant être très toxiques, comme *Aspergillus fumigatus* et *Stachybotrys atra*, n'ont pas été identifiées lors des essais. Cela ne signifie pas que ces organismes n'étaient pas présents dans les logements examinés, mais plutôt qu'ils n'ont pas été retenus comme étant des espèces courantes dans les échantillons d'air et de surface.

L'investigation montre que, à une occasion, les niveaux élevés de bactéries à l'intérieur sont directement attribuables à la présence de terre au sous-sol. Dans d'autres cas, les conclusions sont moins certaines, mais semblent indiquer que, dans les lieux particulièrement propices à la prolifération des moisissures, les responsables des taux élevés de spores aériens seraient les deuxième et troisième types de moisissures les plus courants. C'est pourquoi il se pourrait que des résultats significatifs ne puissent être obtenus qu'en déterminant le genre des trois types de moisissures aériens et en surface les plus courants.

Ce rapport n'analyse pas les résultats du point de vue des effets pathologiques des organismes échantillonnés.

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1. Introduction

In 1988 Health and Welfare Canada conducted a questionnaire-based survey of 30 Canadian Communities. Analysis of the survey results indicated that an association existed between reported home dampness and or mould and respiratory health.(3)

This study is a detailed, in-situ follow-up of a 28 homes which were included in the 1988 survey. The procedures and tests were designed to characterise the functional indoor air quality of the home as well as to determine the level of fungal activity.

In addition to assessment of fungal activity levels, some identification of the fungal genera and species was carried out. Previous studies in this area have suggested that some moulds are more likely to be hazardous to human health than others (Ref. 6).

Emphasis was also placed on a review of the building's physical and operational characteristics which would tend to lead to higher levels of dampness and or mould. As far as possible, the mechanisms which lead to higher levels of dampness and mould were identified.

2. Methodology

Please note that a detailed description of the procedures, materials and methods employed is contained in Appendix A: Protocol.

2.1 Site Selection:

Homes were selected from 141 available homes in the Tillsonburg, Ontario area which had previously responded to the 1988 Survey (3). Homes were not selected on the basis of their survey response questions, but rather on the willingness of the occupants to permit the field team into their homes.

The age of the house varied between 1 and 100 years, with the average age being 30 years.

2.2 Site Visits:

Homes were generally visited on two subsequent days. Most of the sampling and measurement was performed during that period. A third visit was made at least a week later, in order to retrieve the PFT tracer-gas emitters and receivers.

An effort was made to carry out the visits as much as possible during colder weather and, as such, the visits were carried out between January 15th and March 25th of 1991.

2.3 Temperature and Humidity:

Measurements of indoor temperature and humidity were made in the basement and upper level of each house on each visit. Outdoor temperature and humidity was also recorded. A check of the thermostat set point/accuracy was made and the occupant was questioned as to the temperature setback practices employed.

2.4 Measurement and Description:

Each house was measured and a sketch floor plan prepared. Calculated data includes floor area, basement area, volume and envelope area.

The physical characteristics of the building and it's systems was described by an experienced building technologist. General information such as roof, wall and foundation type and condition was recorded as well as interior finishes and window type, construction and number of glazings. Mechanical systems including humidification/dehumidification equipment were examined.

Particular attention was given to any anomalies which might lead to elevated levels of moisture, high humidity, condensation or mould growth.

A check list of observed characteristics and presence or absence of mould at typical sites was completed. This checklist was based largely on the checklist presented in reference 2, which is organized according to level of concern. "A" or primary concern features included items such as: the presence or absence of an open sanitary drain or the presence of birds or bats. "B" level features included items such as the existence of earth floors or the presence of strong mouldy smells. "C" level features included the presence or absence of fungal growth in the attic, existence of closets on outside walls etc.

Significant building features and/or mould sites were photographed.

2.5 Airtightness:

A "Fan-Door" depressurization test was performed with the house prepared by sealing all combustion device flues and combustion air inlets for fuel fired appliances. This corresponds to schedule "A" of the "1989 Survey of Airtightness of New, Detached, Merchant Builder Homes" (Ref. 1) and is the schedule specified in CAN/CGSB-149.10-M86 (Ref. 7).

Calculated data from field measurements includes ELA_{10} (Equivalent leakage area at 10 pascals pressure difference), NLA_{10} (Leakage are per unit area of

building envelope) and AC/h_{50} (Air Changes per Hour at 50 pascals). Calculations were made according to the methods set out in CAN/CGSB-149.10-M86 (Ref. 7).

Additionally, a rough approximation of the anticipated actual air-change rate was made by dividing the AC/h_{50} value by 17 for single-storey homes, by 15.3 for 1-1/2 storey houses and by 13.6 for two-storey homes (Reference 8).

2.6 Infiltration/Air Change:

The Air Infiltration Measurement System (AIMS) Perfluorocarbon Tracer gas (PFT) system as supplied by the National Association of Home Builders (NAHB) Research Division was used to evaluate the actual level of air change being experienced by the homes.

Single zone tests were carried out for periods varying from one week to five weeks with the average being two weeks. Calculated data yielded an average rate of air change which was experienced by the building over the period of test.(4)

2.7 Fungal Air-Sampling:

Samples of airborne mycological content were conducted according to the protocol set out in reference 2, that is; samples were obtained with a centrifugal impingement sampler (Biotest R.C.S.) on standard Rose-bengal-Streptomycin Agar strips. An exception was made in that an 8-minute sampling time was used whereas 4 minutes is specified by Reference 2. This exception was made on the basis of the experience of the study Mycologist and the rational therefore is set out on page 6 and 7 of the Mycologist's Report (Appendix D).

Samples were taken first in the living room and kitchen areas and lastly in the basement area. Basement air samples were taken during the depressurization test, so that the sampler was exposed to air which would have infiltrated through soil and drainage paths if such paths existed.

Outdoor air samples were also taken for each day of sampling, or when houses sampled were not in the same area.

Samples were incubated at 25°C for ten days(2) and the colony count reported as Colony Forming Units per cubic metre (CFU/m^3), calculated according to reference 2.

The number of fungal morphotypes on each indoor strip was reported and the most predominant fungal type in each house was identified as to species.

2.8 Bacterial Air Sampling:

Samples of airborne bacterial content were carried out in the same manner as for Fungi except that no outdoor samples were taken and the sampling media used were Trypticase Soy Agar strips. Outdoor air bacterial sampling was not carried out based on the opinion of the study Mycologist that such sampling would not yield useful information.

Samples were incubated at 30°C for seven days and the colony count reported as Colony Forming Units per cubic metre (CFU/m^3).

The most predominant bacterial species in each house was identified as to species.

2.9 Microbiological surface Sampling:

At least three surface-samples were taken in each house from sites identified by field personnel as most likely to harbour fungal/bacterial growth and included:

- recirculating kitchen range hoods
- exterior wall closets, behind furniture
- refrigerator defrost drain pans
- ducts withdrawing air from areas not separated from cooking appliances
- humidifier trays (portable and fixed)
- dehumidifiers
- floor drains
- obvious mould growth in locations such as:
    - sink overflows
    - bath/tub surrounds
    - damp areas in basement
    - around floor drain in basement.
    - window sills

Samples obtained varied from dry scrapings to moist material and liquid. Samples were prepared and incubated on Trypticase Soy Agar at 30°C for bacterium and Rose Bengal Malt Agar at 25°C for fungi.

Quantitatively, fungal preparations were assigned a sliding scale from 0 to 4 with 0 being "no colonies observed" and 4 being "moderate colonies on 1/10,000 diluted sample"

Bacterial samples were ranked quantitatively by the number of colonies per sample, or number of colonies per millilitre of liquid sample, depending on the type of original sample obtained.

The most predominant bacterial and fungal species for each house was identified as to species.

2.10 Quality Control:

Duplicate fungal air samples were taken for each location in two houses, with the second sample being taken immediately after the first. The samples were assembled together with outdoor air samples and labelled so as to represent three separate houses and submitted to the study mycologist as well as to the quality control mycologist.

Identification to genus of more than the predominant fungal type for each sample was requested in order to allow for variation in the ratio of colony types on the samples. For some samples speciation was requested.

Surface samples were also obtained from the above two houses and submitted as if labelled for three houses.

These samples were analyzed for fungi only, and speciation was carried out for more than simply the predominant species.

Surface samples were obtained as individual samples from the same site.

On one occasion, a blank air sample was submitted to the study mycologist, prepared as an ordinary sample.

On two occasions, simultaneous air samples were obtained and the duplicates sent to Agriculture Canada for analysis. The results from these samples are not available.

3. RESULTS

Tabulated results are presented in Appendix C: Data

3.1 Humidity:

Interior humidity levels were organized and compared according to humidity ratio and indoor/outdoor humidity ratio difference.

Absolute humidity ratios were found to range between 2.3 g/kg and 9.1 g/kg. (Dewpoint -6°C and 13°C). The median dewpoint was approximately 6.1 g/kg (dewpoint 6°C) or about 40% relative humidity at 20°C.

The humidity ratio measurements (average of visits) for basement and upper level areas are comparable for each house (figure 1), and the average of these two figures was used to rank houses by humidity ratio (figure 2).

Relative humidity was calculated but was not deemed to be a reliable indicator of interior humidity levels due to the scatter induced by temperature. As can be seen in figure 3, there is a general relationship between Humidity ratio and relative humidity, but there are also significant deviations. Deviations were usually caused by unusual interior temperatures, for example house #101, which was about 17°C during the visits.

The indoor/outdoor difference in humidity ratio was also calculated, but was not particularly meaningful (Figure 4). It is conjectured that this is due to the storage effects of the building which tend to dampen interior changes in humidity, with respect to outdoor humidity levels which may change quite rapidly. (Exterior humidity levels ranging from 1.0 to 5.8 g/kg were recorded during the study period.)

3.2 Airtightness/Infiltration/Air-Change:

Fan-door and PFT results were organized both by AC/h (air change per hour) and by absolute flow in L/s (litres per second).

The fan-door results which are a measure of house envelope leakiness, were translated into predicted air change rates by dividing the AC/h_{50} value by 17 for bungalows and 14 for two storey houses. There is good agreement between the predicted air-change rates from the fan-door tests and the PFT measured air change rates. (Figure 5 and Figure 6).

For the purposes of comparison to other values the PFT air change result, expressed as an absolute flow, (Figure 7) was chosen as the most meaningful value.

Values of air change were found to range between 0.101 and 1.063 AC/h with a median value of 0.328 AC/h. Absolute values of air change ranged between 15 and 161 L/s with a median value of 52 L/s.

It is useful to note that the recently published ventilation standard for residences, CSA F326, calls for a minimum mechanical ventilation capacity of 0.3 AC/h. 10 of the houses in the study group failed to meet this level of air change, as an average during the measurement period. CSA F326 also allows ventilation capacity selection on a room-count basis. Using this method, a small bungalow would require a 45 L/s minimum capacity. 13 of the houses reported air change rates below this value.

3.3 Fungal Air Sampling (Quantitative):

Airborne fungal spore density levels of 3 to 950 cfu/m^3 were recorded in living areas and 19 to 4630 cfu/m^3 in basements (Figure 8 and Table 1A).

The value obtained from the basement of house #95 at 4630 cfu/m^3 is 300% greater than the next value (from the basement of house #32) at 1531 cfu/m^3, and 2200% greater than the level measured in the kitchen of the same house.

Statistically, the standard deviation for each sample group exceeded the average for living areas and basements, but not in for kitchen areas. (Table 1A).

The was a tendency (with some exceptions) for the airborne fungal density levels to agree on a house to house basis. That is to say that houses with higher fungal counts in the living areas and kitchens tended also to have higher counts in the basement. There was also a certain degree of agreement between living and kitchen areas on a house by house basis (Figure 8).

In general, basement levels were higher than living room and kitchen, although this is not true for all cases (eg; houses #101, 14, 1 & 110). Higher basement levels were expected as a result of the on-site sampling protocol, which involved the depressurization of the house during the basement air sampling period. It was anticipated that this would tend to increase the fungal counts, and bring out fungal matter which might be harboured in foundation wall or floor air passages, or surrounding soil.

For the purposes of ranking the houses, the average value of the three readings was used (Figure 9).

Outdoor fungal density values ranged from 22 to 416 cfu/m^3, and indoor/outdoor ratios ranged from 0.06:1 to 165:1 (Figure 10 and Table 1A). Upper level ratios range from 0.06:1 to 14:1 (Figure 11 and Table 1A).

Statistically, the standard deviation for the kitchen and living area sample sets exceeded the average value by a small margin (Table 1A). For the basement sample group however, the standard deviation exceeds the average value by a factor of almost three. This variability continues to be present (albeit to a lessor extent) even after house #95 (which recorded unusually high fungal concentrations) was removed from the sample set (Table 1A).

For ranking purposes, the indoor/outdoor ratio was calculated as an average of the three sites measured (Figure 12 and Table 1A).

Indoor/outdoor fungal ratio and absolute fungal density are comparable in a general way (Figure 20) and both are used as a measure of fungal activity in this study.

3.4 Bacterial Air Sampling (Quantitative):

Airborne bacterial density levels of 106 to 3906 cfu/m^3 were recorded in living areas and 140 to 2875 cfu/m^3 in basements (Figure 13 and Table 1A).

Significant variations were recorded between locations in individual houses, for example house #76, in which a value of 1000 cfu/m^3 was recorded in the basement, and 3900 cfu/m^3 in the kitchen.

Bacterial levels do not show the same distribution patterns as fungi in that the basement levels are not generally higher, and the standard deviation for all groups is below the average (Table 1A).

For the purposes of ranking, the airborne bacterial density was calculated as the average of three sites. (Figure 14 and Table 1A).

3.5 Surface Sampling (Quantitative):

In terms of the sites which were selected by the field technicians as most likely to harbour bacterial/fungal growth, windows were the most frequently selected sample sites (23), followed by refrigerator drain pans (11), humidifier pans (8), and bathtub/shower enclosures (5) and floor drains (5) (Table 1).

In terms of fungal productivity (Table 2), the top-ranked surface samples of refrigerator gasket, cold room floor and laundry window are all single-location samples. Among locations for which a range of sites are available, (5 or more sites), bathtub/shower enclosures were the most productive, followed by master bedroom windows. Basement windows, floor drains and refrigerator drain pans occupy the middle ground, and humidifier pans and furnace filters are not particularly productive with respect to fungi.

With respect to bacterial productivity (Table 3) bathtub/shower surrounds, floor drains, basement walls and floors, sump holes, humidifier pans, kitchen sinks, various windows and refrigerator condensate trays are all quite productive (over 20,000,000 colonies per millilitre). Dry refrigerator drain pans, the refrigerator gasket, a water pipe, a range hood filter and furnace filters are not very productive (less than 3,000 colonies per millilitre).

3.6 Fungal Sampling (Qualitative)

From those fungi selected as predominant from each set of surface and air samples, a total of 29 different fungal species were identified. These species and the locations where they were collected are shown in Table 6.

The most popular species identified are Cladosporium herbarum (13 out of 56 samples) and C. cladosporioides (6 out of 56 samples). Only these two species could be said to be found frequently in both air and on surfaces. Aspergillus ornatus, Aureobasidium Pullulans and Rhodotorula rubra did occur as predominant fungi on both air and surface samples but only as single occurrences. For the majority of the predominant fungi (24 out of 29), they were found to be predominant in air, or on surfaces, but not both.

Comparison of the predominant fungal species with those which are identified as "Reported to be Toxigenic" in Table I of Reference 6, and those that are listed as "Mycotoxin producers" in Table II of Reference 6, was carried out and the results are shown in Table 6A.

10 species (out of 29) were identified as "Reported to be Toxigenic" or "Mycotoxin producers" according to Reference 6. 29 samples (out of 56) were identified as "Reported to be Toxigenic" or "Mycotoxin producers" according to Reference 6.

Many other genera and species were identified from the samples which were subjected to more detailed fungal analysis. These results are set out in Tables 10 and 11.

Many of the species identified in the detailed analysis were also identified as predominant species in other houses, and an approximately equal number were not. Typically, a much larger variety of fungal species was identified in air samples than in surface samples.

From the two houses for which detailed fungal analysis was carried out, a total of 46 fungal colonies were identified to species. Of these, 14 were identified as "Reported to be Toxigenic" or "Mycotoxin producers" according to Reference 6.

The known toxic fungi Aspergillus fumigatus and Stachybotrys atra were not identified. This does not

mean that they did not exist in some of the houses. Rather, it can only be said that they were not identified as the predominant fungal species, and they were not present on the samples from two homes which were subjected to detailed fungal analysis.

3.7 Bacterial Sampling (Qualitative)

From those bacteria selected as predominant from each set of surface and air samples, a total of 25 different bacterial species were identified. These species and the locations where they were collected are shown in Table 7.

The most popular species identified are Micrococcus luteus (5 out of 47 samples), Pseudomonas fluorescens (4 out of 47 samples), Staphylococcus haemolyticus (4 out of 47 samples), and S. warneri (4 out of 47 samples). A more detailed discussion of the bacterial species identified is presented in Appendix D: Mycologist's Report.

3.8 Relationship of Predominant Air Species to Surface Sample Predominant Species

In house number 114, Bacillus cereus was identified as the predominant airborne bacterium in air from the basement air sample, (2875 cfu/m^3) and was identified as the predominant bacterium in the basement soil sample (1,500,000 colonies per millilitre). No other examples of direct correspondence of surface and air samples were found for bacterium.

In house number 99, Cladosporium herbarum was identified as the predominant airborne fungus in air from the basement air sample, (109 cfu/m^3) and was identified as the predominant fungus in the bathroom window surface sample (level 2 fungal density). No other examples of direct correspondence of surface and air samples were found for fungi.

In order to define any patterns which might exist with respect to typical locations, Tables 6 and 7 were assembled based on the locations of the isolated predominant bacterial and fungal species for all houses.

For the bacteria (Table 7), only four species were found to be predominant in air and also surface samples:

Bacterial Species	Air Sample	Surface Sample
Bacillus cereus;	Basement	Basement soil
Acinetobacter geno sp.;	Basement	Cold room ceiling
Corynebacterium sp.;	Kitchen	Child's window
Micrococcus luteus;	Various	Bath-shower surface (1)

For the fungi (Table 6), five species were found to be predominant both in air and in the surface samples:

Fungal Species	Air Sample	Surface Sample
Aspergillus ornatus;	Basement	Closet ceiling-wall
Aureobasidium sp;	Basement	Child's window
Cladosporium cladosporoides;	Basement(2)	Bath-shower surround(2), Dehumidifier pan, Refrigerator drain pan.
Cladosporium herbarum;	Basement(2) Kitchen(2), Living area	Refrigerator drain pan, Refrigerator gasket, Bathroom window (2), Child's bedroom window, Cold room ceiling, Floor drain, Basement wall.
Rhodotorula rubra;	Kitchen	Laundry window

3.9 Detailed Air-Surface Site Relationships

As part of the quality control procedure, the quality control laboratory was given two sets of air and surface samples for counting, and identification to genus. Some of these samples were also to be identified to species. This laboratory analyzed all of the observed fungal colonies with the exception of yeasts, which were identified as "yeasts" with an observation that many of the yeasts were probably Rhodotorula sp. because of the reddish colouring. When organized according to site, these samples offer some insight into the actual numbers and varieties of fungi in closely related sites.

Table 10 sets out the detailed findings for house #32, which is one of the most microbiologically active homes, having an overall score of 2 (see Identification of Mechanisms, score is a ranking from 1 to 28 with 1 being the most microbiologically active).

The predominant indoor air fungi are species of Penicillium, but the source of the airborne fungi is not clearly indicated. Penicillium is present at most of the surface sites, but not in overwhelming numbers. Fusarium sp. was identified in the kitchen air sample, but not on any of the surface sites.

The second most popular genus in air samples was Cladosporium sp.. All of the indoor levels of this genus are lower than the outdoor level, and this genus was also identified at two of the surface sites, although not as a predominant variety.

Epicoccom sp. is found in the outdoor sample at a concentration of 3 cfu/m^3 and in the kitchen air sample at 6 cfu/m^3 and in the basement air sample at 9 cfu/m^3.

This implies that there is also an indoor source for this fungus, although one was not identified.

Aureobasidium sp. was present in all the surface samples but only present in one air sample (the bedroom) and then only as one of the least numerous types.

Aspergillus sp. was present in the Refrigerator drain pan sample and in the bedroom closet sample. In air, it was isolated in the basement, living room and kitchen.

Alternaria sp. was isolated in the bedroom window sample only. In air it was isolated in the living room, kitchen and outdoors.

Ulocladium sp. (as Ulocladium chartarum) was identified only on the bedroom window surface sample. In air it was isolated in the kitchen and living room samples as one of the least numerous genus.

Acremonium sp. was isolated from the kitchen air sample; Botrytis cinera, Geomyces pannorus, and Scopulariopsis fusca from the bedroom air sample; and Chaetomium globosum, Chaetomium sp., Eurotium repens, Rhizopus nigricans and Beauveria bassiana from the basement air sample. These genus were not identified in any of the surface samples.

Table 11 sets out the detailed findings for house #126, which has an overall score of 8 in terms of microbiological activity.

Predominant indoor air fungi are Aspergillus versicolour in the kitchen air and Penicillium sp. in the living room and basement. The source of the Aspergillus is not clear as it was only isolated from one of the HRV samples and from the sump water, and not in large numbers for either of these sites. Penicillium was isolated from one of the HRV samples and from the freezer gasket in moderate numbers. Considering that the freezer is located in the basement, it is a plausible source for the basement air spores, however the surface area of growing fungi presented to air is not large.

Aureobasidium sp. was present in moderate numbers in all of the surface samples and in high numbers in the freezer gasket sample, and the refrigerator drain pan. (Aureobasidium pullulans identified in the refrigerator drain pan and HRV Pan samples.) Aureobasidium sp. (as Aureobasidium pullulans) was only isolated in the kitchen air, and then only as one of the least numerous fungi.

Cladosporium sp. was the only genus identified in outdoor air, and was identified in all the indoor air samples. The basement concentration of 119 cfu/m^3 was approximately double the outdoor concentration. Cladosporium was isolated on the freezer gasket and one of the HRV samples. As for the case of Penicillium, the freezer gasket appears to be a plausible source,

particularly in light of the higher basement air concentrations of this fungus.

Scopulariopsis fusca was identified in the kitchen air sample, and Alternaria sp. and Epicoccum sp. in the basement air sample. These genus were not isolated in any of the surface samples.

Mucor sp. was found in moderate quantity in the basement air sample and in very small concentration in the sump water sample.

3.10 Identification of Mechanisms:

Each house was assigned a rank from 1 to 28 based on the following criteria:

a. Airborne fungal density, (average of 3 sites)
b. Indoor/outdoor fungal density ratio
c. Airborne bacterial density, (average of 3 sites)
d. Subjective mouldiness (observation by the field technician)

The above ranking factors were summed (with equal weight to each) to arrive at an overall ranking. Because two measures of fungal activity are included, the scoring system is recognized to have a bias towards higher levels of airborne fungi, although this is not strictly a measure of mouldiness, because of the inclusion of airborne bacterial density. This ranking is called the Overall Microbiological Score

These rankings, together with key observational notes and a description of the mechanisms likely to lead to higher levels of mould and bacterium, are presented in Appendix B.

The group of 14 houses which had the highest overall level of microbiological activity were reviewed and the causative mechanism enumerated in Table 4. The most frequently identified (4 each) mechanisms are:

i. Low rates of air change; and,
ii. Exposed soil in basements or crawlspaces

3.11 Relationship to Low Air Change Rates:

There is no apparent relationship between the rate of air change and the overall microbiological score. While low air-change has been identified as a causative mechanism in several of the more microbiologically active homes, Figure 24 shows that this is case-specific. There are several cases of high microbiological activity in houses with high air-change rates (eg house #95) and cases of low microbiological activity in houses with low air-change rates (eg house #84 and house #99).

3.12 Relationship to Higher Humidity Levels:

There is no apparent relationship between interior humidity levels and the overall microbiological score. While higher moisture levels resulting from several causes have been identified as mechanisms in several of the more microbiologically active homes, Figure 25 shows that this is case-specific. There are several cases of higher microbiological activity in houses with low moisture levels (house #'s 95, 131 and 126)and cases of low microbiological activity in houses with higher moisture levels (eg house #1 and house #99).

3.13 Identification of Features/Equipment/Observations

In order to identify particular house construction features, equipment, operating practices or observable phenomenon which would lead to, or indicate higher levels of microbial activity, an enumeration of such features from the field notes was made. This enumeration was organized into two groups;

i. those 14 houses with the highest microbiological activity (according to the overall score), and;

ii. those 14 houses with the lowest activity,

and is presented as Table 5.

In most instances the results of this enumeration are inconclusive, however some of the particular observations which may be drawn however are as follows:

a. Parged foundations are more often found in houses with low microbial activity, but other features of foundation construction and condition do not show any trends.

b. Moisture in the attic is more often reported in houses with higher microbial activity, but the observance of attic fungi is comparable for both groups.

c. Finished basements and carpeted basements occur more often in the group with lower microbial activity.

d. Houses with crawlspaces are more numerous among houses with higher activity.

e. The distribution of houses with current basement leakage and which reported previous flooding was approximately uniform.

f. Houses equipped with central air conditioners are more often found in the group with lower microbial activity.

g. Bath fans which are vented into the attic were found only in high-activity houses.

h. An approximately equal number of baseboard and forced-warm air heating systems was found in each group.

i. Filters in good condition were usually found in houses with higher microbial activity and filters in poor condition were only found in houses with low microbial activity.

j. There is a tendency for wood, electric(or heat-pump) and oil heating systems to be found in house with higher activity levels, and gas heating systems in houses with lower activity levels.

k. There are no apparent trends according to heating system draft type, but there may be a tendency for sealed or non-combustion water-heaters to be found in houses with higher levels of microbial activity.

l. There are more furnace-mounted humidifiers in low activity houses, but the humidifiers in high activity houses are used more overall.

m. There is only a slight tendency for dehumidifiers to be found in houses with low microbial activity.

n. Set-back of space heating temperature is more likely in higher-activity houses, and for longer period of time.

o. Mouldy ceilings are most often found in higher activity houses and mouldy walls are only found there.

p. Mouldy smells (and in particular from the basement) were reported most often from the houses with higher activity levels. Mouldy smells from drains were only reported from low-activity houses.

q. Condensation on windows occurs more often in higher-activity houses but a significant number of occurrences (6) were reported from low-activity houses.

r. There is only a slight tendency for high-activity houses to have more plants.

3.14 Finished Basements, Dehumidifiers and Air Conditioning

Additional analysis was carried out on the overlap of finished basements and devices which would tend to alleviate the traditional "summer basement dampness" problem. The results of this analysis is shown at the end of Table 5.

The results show that houses with finished basements are by and large equipped with either a dehumidifier or a central air conditioner. Houses which are equipped with both a dehumidifier and a central air conditioner are only found in the low-activity group. There is also a strong tendency for houses with finished basements and central air conditioners to found in the low activity group and there is a moderate tendency for houses with finished basements and dehumidifiers to be found in the low activity group.

3.15 Relationship to House Plants:

As noted previously, only a slight tendency for higher microbiological activity was recognized with respect to the number of house plants.

With respect to specific fungi, it was found that those houses with a higher number of house-plants (more than 10) tended to show Cladosporium sp. as the predominant species more frequently (50% of samples) than the entire group (27% of samples).

Two houses were identified with Cladosporium sp. as the predominant genus in both air and surface samples. These houses (#99 and #43) ranked 26th and 18th in terms of overall microbiological activity.

3.16 Quality Control:

A comparison of colony and morphotype counts obtained by the study laboratory "Lab A" and the quality-control laboratory "Lab B" is presented in Table 8. With respect to the number of morphotypes reported on air samples, Lab B tends to report a lower number than Lab A (Figure 26). This is repeated for the air sample colony counts (Figure 28). It is possible that Lab B counted the colonies earlier than the full 10-day incubation period which was used by Lab A.

There is a general relationship between the number of morphotypes reported by the two labs (Figure 27) for surface samples. The colony counts reported by the two labs are not comparable, however. Lab A reported colonies on a semi-logarithmic scale of 0 to 4, whereas Lab B reported colonies as "CPU" for the entire sample. Additionally, the sample collection method of taking individual samples from the same site (rather than taking a single sample, homogenizing and dividing), is expected to introduce variations in sample counts.

With respect to species identification, the results of the two labs are listed in Table 9. While there are many instances of good agreement to genus (samples A327/A329 for example), there are some samples in which the genus identified as predominant by Lab A is absent from the corresponding sample analyzed by Lab B (samples A3210/A3212 and S1262 for example).

Unfortunately, the air samples were not able to be taken simultaneously, rather they were taken immediately sequentially in the same locations, which may have introduced some variation in the actual varieties captured.

In sample A3213, Lab A identified Penicillium rugutosum as the predominant species, and Lab B identified seven other varieties of Penicillium for it's corresponding air sample (see sample A3215, Table 10) but not P. rugutosum.

With respect to the blank sample, it was analyzed as having a colony count of "less than 3".

4. DISCUSSION

4.1 Moisture/Dampness/Humidity/Air Change

Many features which lead to high levels of moisture and dampness were identified and included:

a. Open soil crawlspaces and basement floors

b. Basement water entry

c. Low levels of air change

d. Poor local air circulation (room to room)

e. Excessive humidification.

f. Low indoor surface temperatures/condensation

In addition, many houses were identified which exhibited high levels in indoor humidity.

Figure 15 shows that there is a strong relationship between the level of indoor humidity and the air change rate for any given house that is; houses with lower air-change rates exhibit high levels of indoor humidity.

The premise that houses which have higher levels of indoor relative humidity have higher levels of fungal or microbiological activity is not supported statistically by the group of homes examined in this study. Figures 21, 23 and 25 demonstrate the absence of any particular relationship of the indoor humidity ratio to airborne fungi, airborne bacterium, or the house's overall microbiological activity ranking.

The premise that lower levels of air-change contribute to higher levels of microbiological activity is also not supported statistically by this group of houses. Figures 16, 17 and 18 demonstrate that there is no particular relationship between fungal density in indoor air, bacterial density or indoor/outdoor fungal ratio with air-change rate. Figure 24 shows that there is only a modest trend for houses with higher microbial activity to have lower air-change rates. However, it also shows that houses with Air-change rates which are considered to be quite low are not particularly active, microbiologically.

The premise that houses with moisture-related faults such as water leakage, damp basements or previous flooding are more microbiologically active is not supported statistically by the group of homes in this study. From Table 5 it can be seen that incidence of basement leakage, previous flooding, or type and

condition of basement have little or no relationship to the level of microbial activity.

It was expected that house with finished basements would exhibit higher levels of microbial activity, due to exacerbation of the traditional "summer basement dampness" problem. The numerical results indicated that in fact, there was a slight tendency for the opposite to be true. On further examination, it was found that houses with finished basements tended also to be equipped with devices which would alleviate the summer interior humidity levels, such as dehumidifiers or central air conditioners. Only one 1 of 17 finished basement houses did not have a dehumidifier or a central air conditioner.

For these houses it appears that the presence of a central air conditioner has a strong effect on the reduction of microbial activity, and that dehumidifiers have a much less strong effect. All of the houses (six) which were equipped with both a dehumidifier and a central air conditioner were in the lower range of microbial activity.

Other indicators of high microbiological activity suggested in Reference 2 such as the existence of carpeting in the basement, existence of ceiling fans or cathedral ceilings, dirty filters, trees or shrubs against the house, and the existence of fungi in the attic were found to be inconclusive. In fact, clean filters were found more often in houses with higher microbiological activity (Table 5).

Notwithstanding the above it was found that in most houses, the cause of higher microbial activity could be identified and that the cause would fall into one or more of the above categories. As it happens, houses with leaky basements sometimes have high rates of air leakage and are quite dry. Some houses with high levels of interior humidity, which were quite air-tight did not register as highly active from a microbiological point of view. Similarly houses which reported previous flooding or active basement leakage did not necessarily exhibit high levels of microbial activity. A review of causative mechanisms is show in Table 4.

A more detailed examination of the mechanisms which involve condensation of water on surfaces due to low surface temperatures or high humidity (high dewpoint temperature) is given in the following section.

4.2 Condensation/Operation of the House:

Many features/practices which lead to condensation of moisture on building surfaces were identified such as:

a. Single-glazed windows

b. Windows with poor thermal breaks in the frame.

c. Uninsulated exterior walls (in particular foundation walls).

d. The use of portable, local humidifiers, usually in bedroom areas, usually overnight. In one case, the use of such a device resulted in significant mould growth in the bedroom area whereas mould growth was virtually absent in all other areas of the home.

e. The use of window coverings and draperies which restrict the movement of air and heat to the window glazing and frame.

f. Excessive temperature set-backs. In this situation the temperature of a house (#101) was allowed to sink as low as 40°F during the day when no-one was home. Although the home did not have a particularly high moisture level, (HR 7.2 g/kg), the actual air temperature may have descended below the dewpoint temperature of 9°C on cold days. Certainly most exterior surfaces in the house showed evidence of repeated condensation events and subsequent mould growth. Additionally, this house showed the lowest PFT-measured air-change, while the airtightness was ranked 5th. This discrepancy is explained by the lowering of the stack effect which would normally be expected to drive the air-change rate, if normal temperature differences were present at all times.

Condensation on a window, for example, was not found to be an indictor of high microbial activity levels. But, in many situations, it was unsightly and damaging to the window and or surrounding surfaces. With respect to windows in particular, it is useful to note that often it is newer windows, rather than old, which exhibit a poor thermal break around the glass edge, which leads to condensation and subsequent mould growth.

Condensation is linked to household operation in that, even though condensation may occur due to the construction of a particular item (ie a poorly insulated wall), it is ultimately controlled by the operation of the building. That is to say, if the interior humidity is reduced sufficiently by ventilation or restriction of humidity-producing activities, then the condensation will be avoided. Very

poor construction, such as single-glazed windows for example, often require humidity levels to avoid condensation which are actually uncomfortable, and which most persons have been conditioned not to accept.

It is clear that for many persons, the interaction of higher humidity levels, condensation and mould growth is poorly understood, ignored, or considered less important than other issues in their daily lives. In most of the instances where condensation and mould growth was linked to a operation issue, such as the use of a humidifier or temperature set-back, the occupant had little awareness of the mechanism which led to the resulting condensation and fungal growth. In most instances the fungal growth was considered to be a cosmetic annoyance only. In those instances where lack of ventilation was an issue (house number 32 and house number 101) the governing concern was to minimize heating costs, and the fungal growth was viewed as an annoying simultaneous occurrence.

4.3 Appliances:

Many instances of mould and bacterium growth were found in certain household appliances. These appliances included humidifiers, dehumidifiers and refrigerators.

The design of the refrigerator has a lot to do with the amount of mould/fungi present. Certain designs almost always had some growth, others never. In general, this was related to the position of the condensate tray with respect to the condenser and compressor. Those which had the tray above the condenser or compressor (or immediately adjacent) so that the water evaporated quickly (source of heat) never had any growth. Others particularly those in which the tray was completely below all the heat-generating parts, almost always exhibited growth. (one did not house #131, but on inquiry, the occupant admitted that she had recently cleaned it.) In some cases (house #101) these pans were completely overrun with growth.

It was theorized prior to the field work that recirculating range hoods would yield significant fungal and/or bacterial activity, but this was not confirmed by the field observations or by the samples analyzed.

Only one house was found without the dryer being properly connected (House # 95). This feature does not appear to be connected with the high levels of airborne fungi, as the dryer was located in the "mud room" on the first level and the high levels of fungi were recorded in the basement.

Some microbial activity was identified in the fresh-air intake system of the only HRV found in the sample.

Humidifiers, and in particular furnace-mounted humidifiers, did not yield the fungal and bacterial productivity that was expected. Portable, drum-type humidifiers were found to be quite productive however.

4.4 Airborne Fungal Density:

Reference 2 suggests that, for individual samples which contain a variety of species (other than Alternaria and Cladosporium), values over 200 cfu/m^3 warrant "further investigation". 14 houses in the sample group exceed this criterion. This paper also suggests that samples over 500 cfu/m^3, principally Cladosporium Sp. and Alternaria Sp., should also be investigated. 7 houses in the study group exceed this criterion.

It is clear from Figure 20 that for levels of fungal density below 200 cfu/m^3, the indoor/outdoor fungal ratio is a more useful indicator of activity. This occurs because of the variation in outdoor airborne fungal densities ranging between 22 and 416 cfu/m^3. At least 5 measurement days out of 28 recorded outdoor fungal levels at or higher than 200 cfu/m^3.

In this study, identification of the type of fungi on the outdoor air samples was not carried out except for the detailed study carried out for houses 32 and 126 (Table 10 and 11). From the results of the detailed study, it is possible to foresee a situation in which the indoor and outdoor samples might have a similar count, but be almost entirely different with respect to genus and or species. In addition, when considering the source of a particular fungal type, it is useful to be aware of those types contained in outdoor air.

4.5 Airborne Bacterial Density:

Reference 5 quotes airborne bacterial levels of up to 12000 cfu/m^3 in problem homes. Reference 5 also quotes the highest expected "normal" level of airborne bacterial concentration as 4500 cfu/m^3. On this basis, it appears that the levels recorded in this study are not unusual.

The bacterial density did not appear to have any particular relationship to fungal density levels (Figures 19 and 22) or to humidity (Figure 23), or to air change rate (Figure 17).

In one case the predominant airborne bacterium was also identified as the predominant bacterium in the basement

soil (which was exposed). Other houses with high levels of airborne bacterium were also found to have exposed soil conditions.

With respect to this feature (exposed soil and crawlspaces), it appears that the conditions found in a basement "cold-room" are quite similar, and these yield surface samples with significant mould and bacterium levels (Tables 2 and 3).

4.6 Identification of Fungal Type and Species:

In general, the approach taken of identifying only the predominant species from air and from surface samples, and not from outdoor air, did not yield any significant knowledge except for the positive source location cited for the exposed soil bacterium above (house #114).

In another house, the fungal species identified was the same for surface and air samples, but it was identified as predominant in the basement air sample, and in the bedroom-window surface sample.

The detailed identification work carried out for house numbers 32 and 126 was much more revealing, with respect to identifying mechanisms and sources, even when the identification was only carried out to genus. It is clear that, in some situations, the predominant airborne fungus may only be the second or third most popular variety at a certain site. In these two houses, over 50% of the airborne fungi were also isolated at surface sites.

As concerns those fungi identified in Reference 6 as "Reported to be Toxigenic" or "Mycotoxin Producing", it seems that the identification of the predominant fungi to species does not yield as much information as the detailed identification procedures. For example, in house # 32, Penicillium herquei and P. rugulosum were identified as the predominant airborne fungal species. Neither of these is identified in Reference 6 as being potentially toxic. From the detailed identification however, there are 5 other, less numerous species which exist in this house, which are listed as potentially toxic in Reference 6.

The fact that such known toxic fungi such as Aspergillus fumigatus and Stachybotrys atra were not identified in this study does not mean that they did not exist in some of the houses. Rather, it can only be said that they were not identified as the predominant fungal species.

Discussion of the medical/pathological implications of the findings is beyond the scope of this report.

5. REFERENCES:

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3. The Canadian Air Quality Health Survey: Influence of Home Dampness and Moulds on Respiratory Health, R. Dales, M.D.; H. Zwanenburg, M.D.; R. Burnett, PhD; Health Protection Branch, Health and Welfare Canada.

4. Evaluation of Perflourocarbon Tracer Technique for Determining Infiltration rates in Residences, B. P. Leaderer et al., Environmental Science and Technology, Vol.19, No. 12, December 1985, Pp. 1225-1232.

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8. Infiltration: Just AC/h50 divided by 20?, Energy Auditor and Retrofitter (now Home Energy), July/August 1986, pp 16-19, Alan Meir, Based on the work of Alex Sherman of Lawrence Berkeley Laboratories, as described in the paper "Estimation of Infiltration from Leakage and Climate Indicators" by Alex Sherman.

   Using the formula F=C*H*S*L, where:

   C= Climate factor (17 used for Southern Ontario)
   H= Height factor
   S= Shelter factor, 1= normal
   L= Looseness factor, 1= normal

   For a single storey; H=1.0, S=1.0, L=1.0, Factor=17
   For a 1-1/2 storey; H=0.9, S=1.0, L=1.0, Factor=15.3
   For a two storey; H=0.8, S=1.0, L=1.0, Factor=13.6

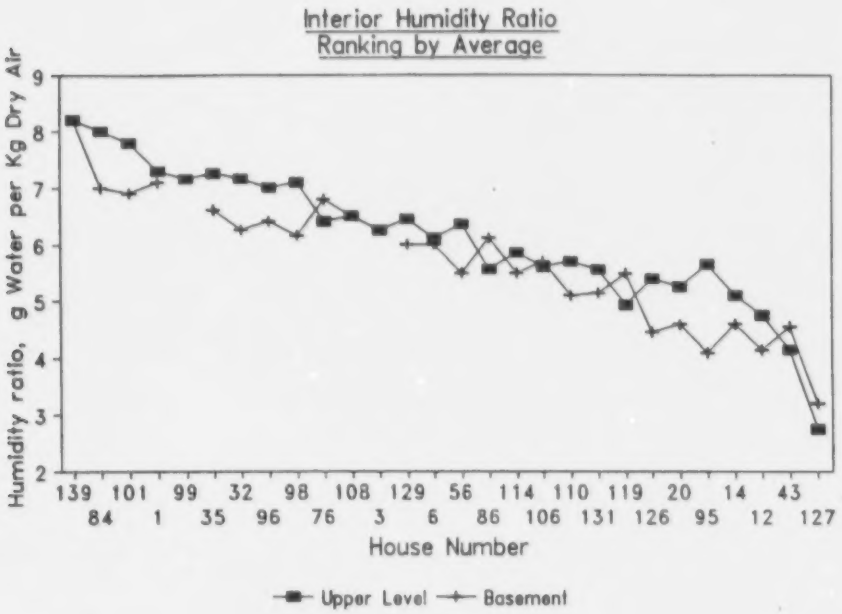


FIGURE 1

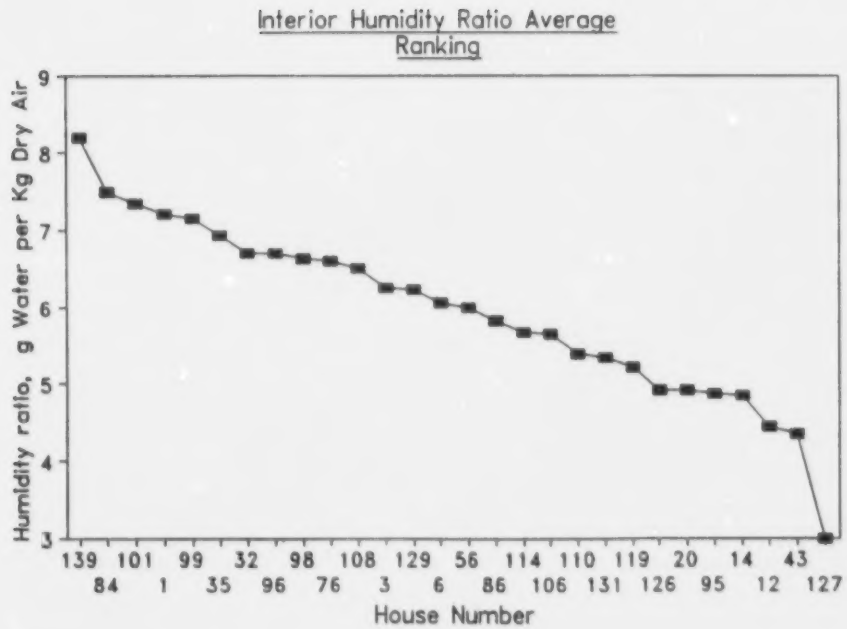


FIGURE 2

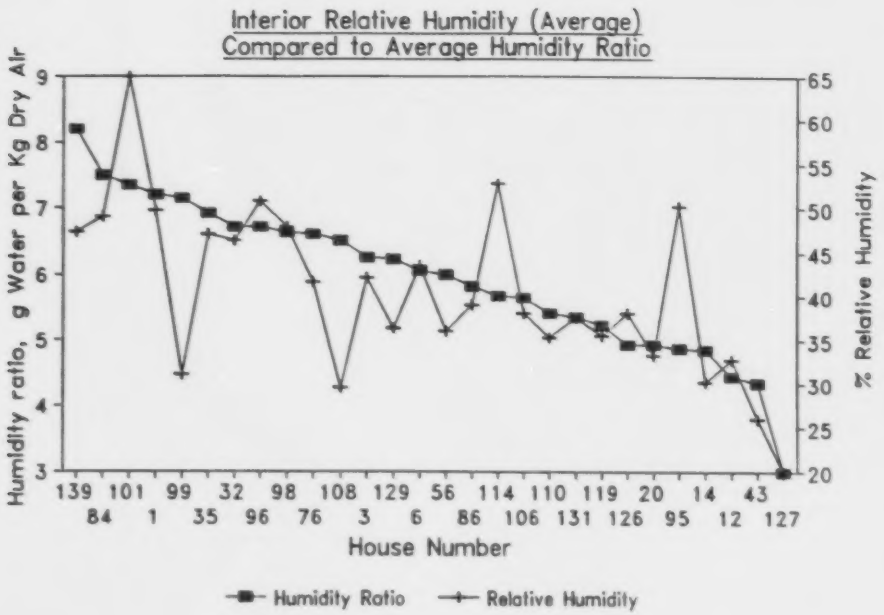
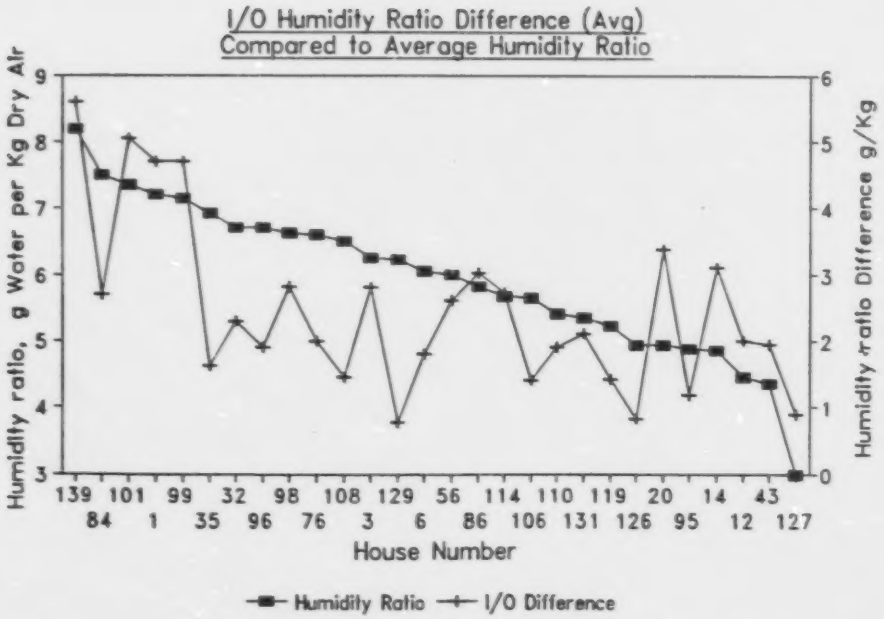

Interior Relative Humidity (Average)
Compared to Average Humidity Ratio
Humidity ratio, g Water per Kg Dry Air
% Relative Humidity
House Number
139 101 99 32 98 108 129 56 114 110 119 20 14 43
84 1 35 96 76 3 6 86 106 131 126 95 12 127
Humidity Ratio
Relative Humidity

FIGURE 3


I/O Humidity Ratio Difference (Avg)
Compared to Average Humidity Ratio
Humidity ratio, g Water per Kg Dry Air
Humidity ratio Difference g/Kg
House Number
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84 1 35 96 76 3 6 86 106 131 126 95 12 127
Humidity Ratio
I/O Difference

FIGURE 4

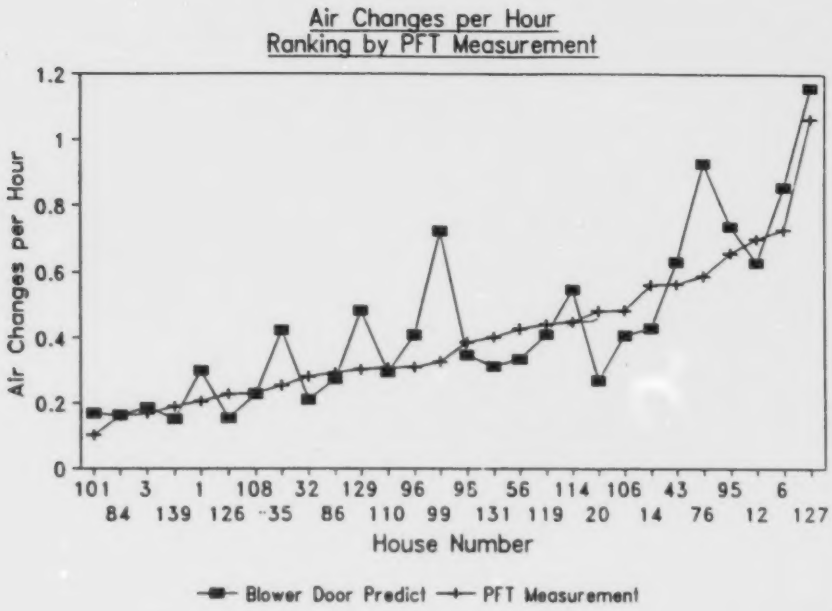


FIGURE 5

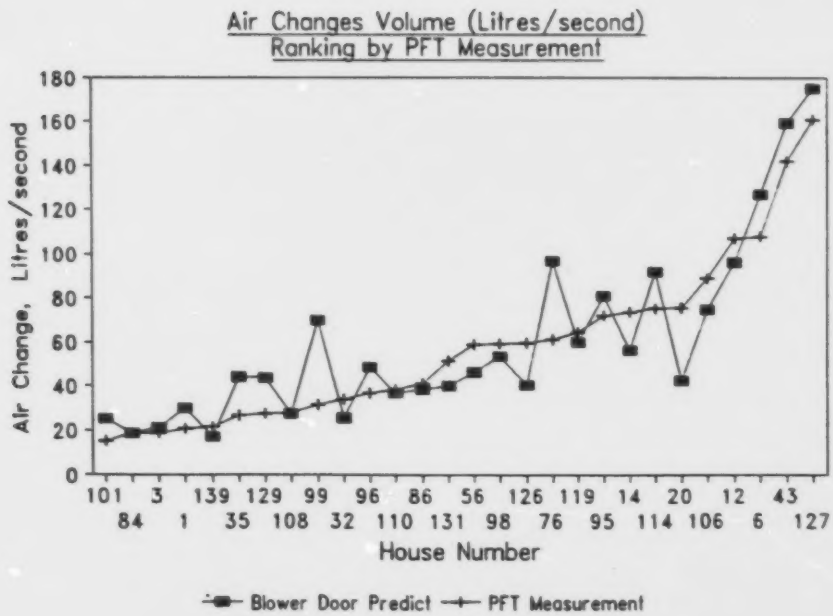


FIGURE 6

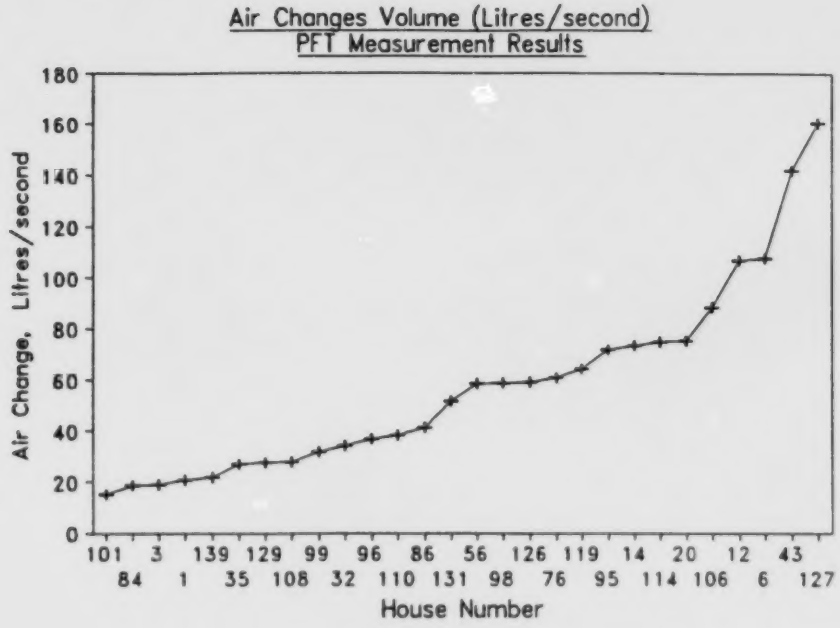


FIGURE 7

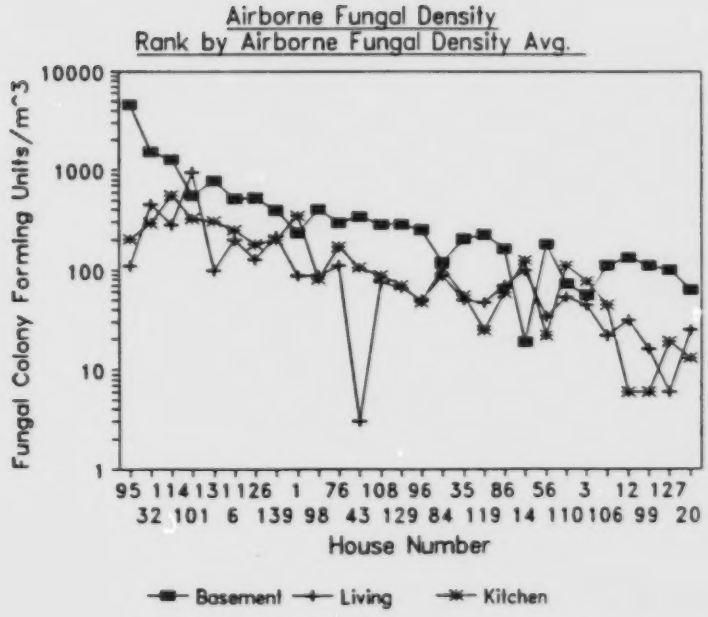
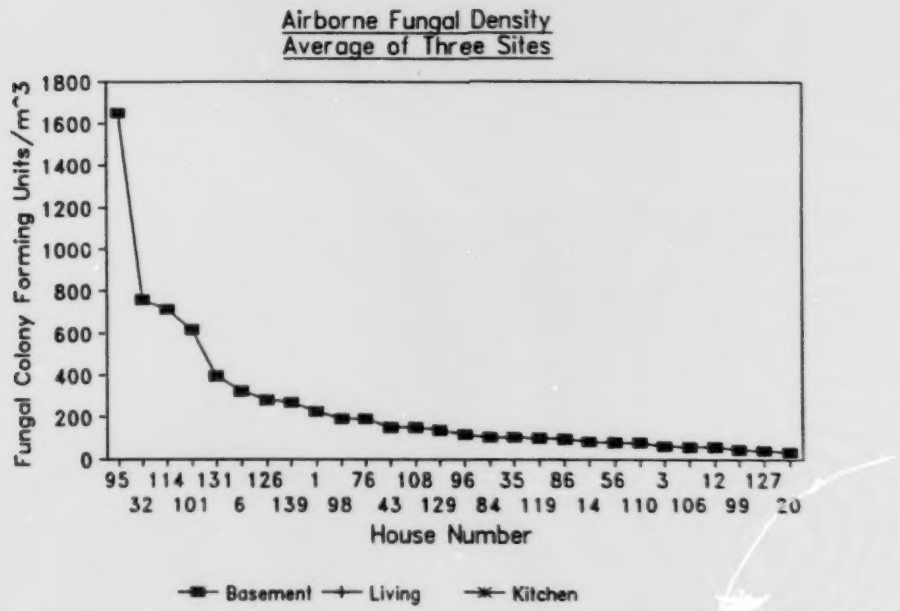


FIGURE 8



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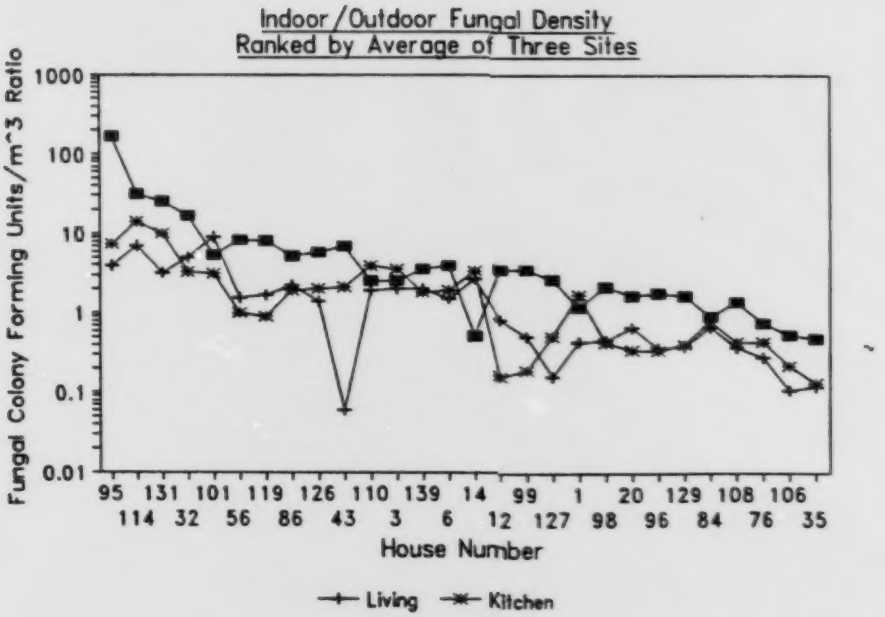


FIGURE 10

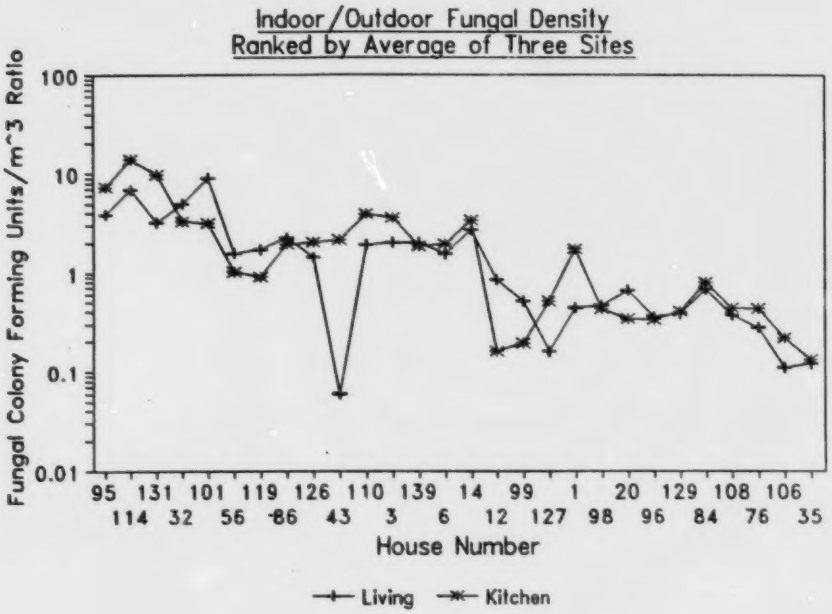


FIGURE 11

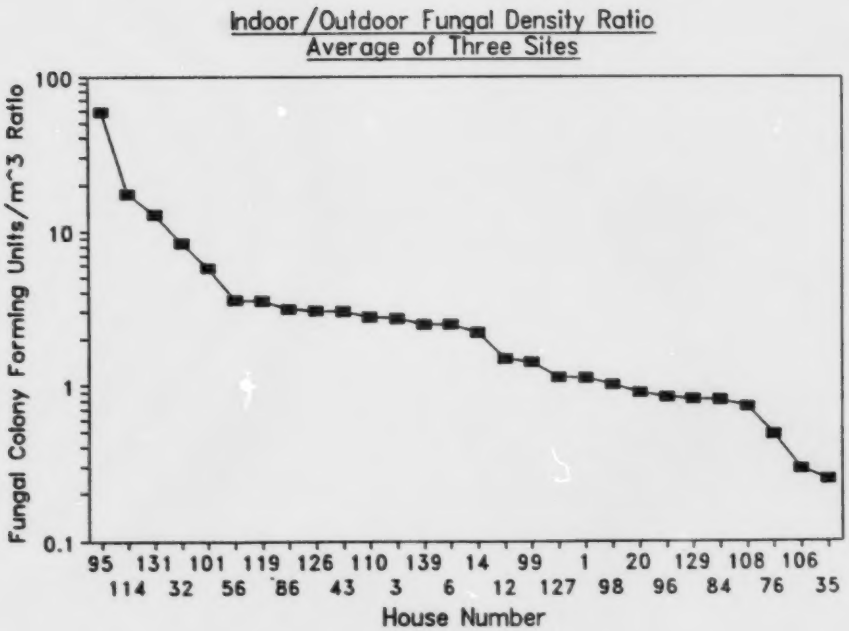

Indoor/Outdoor Fungal Density Ratio
Average of Three Sites
Fungal Colony Forming Units/m^3 Ratio
100
10
1
0.1
95 131 101 119 126 110 139 14 99 1 20 129 108 106
114 32 56 86 43 3 6 12 127 98 96 84 76 35
House Number

FIGURE 12

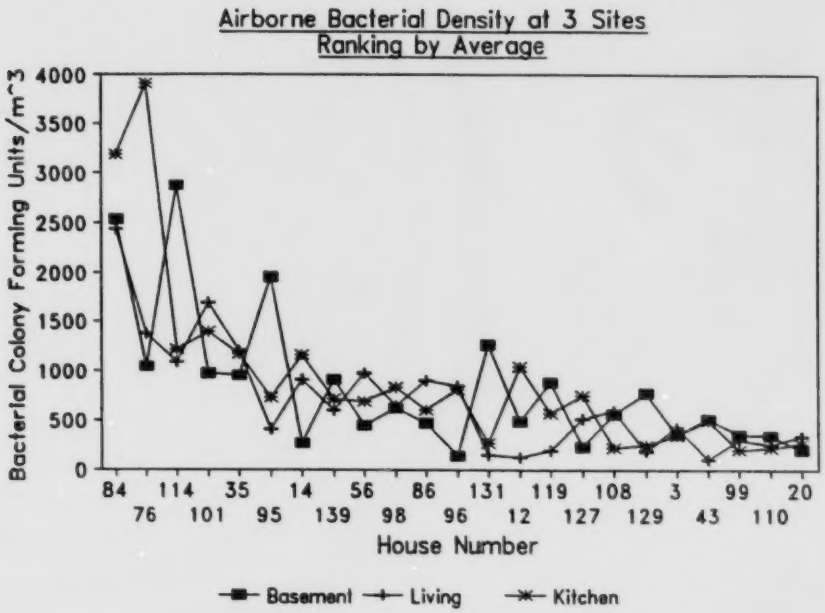


FIGURE 13

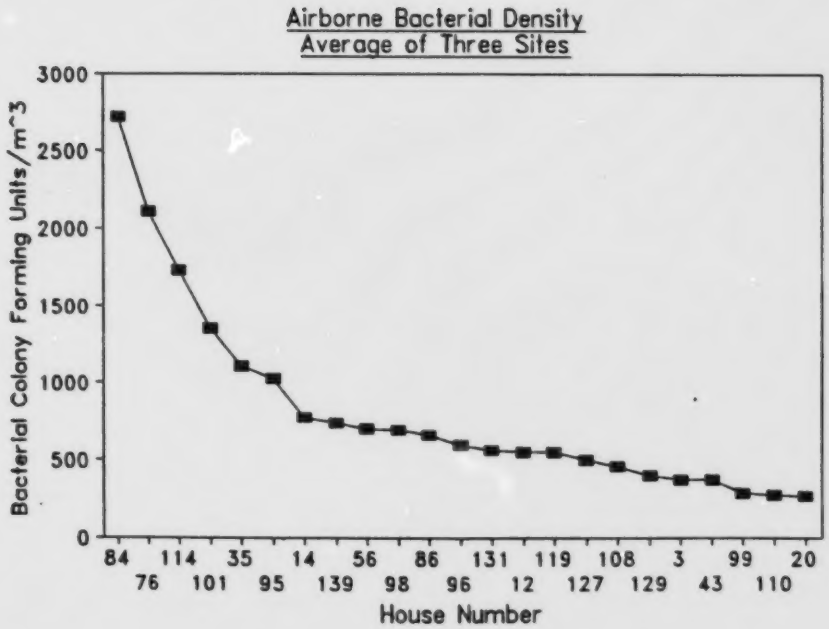


FIGURE 14

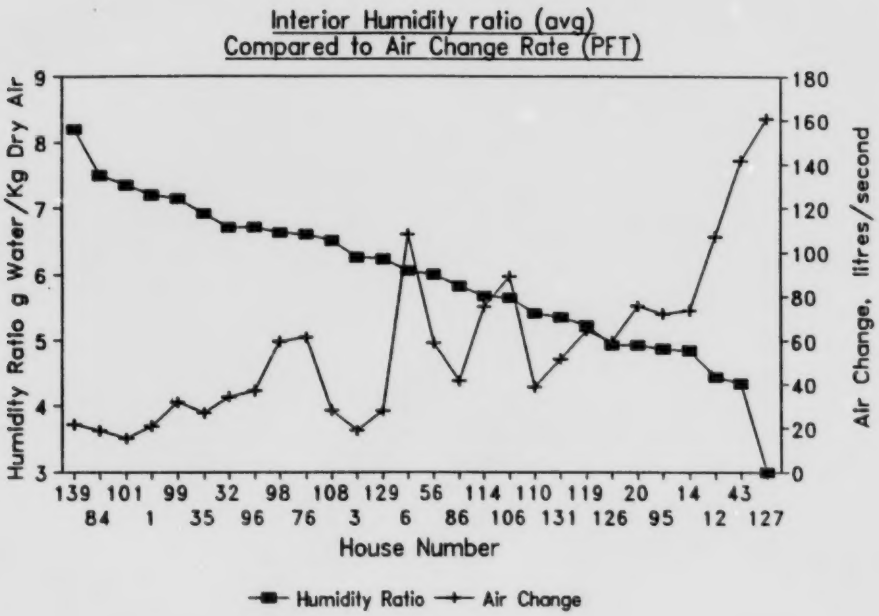

Interior Humidity ratio (avg)
Compared to Air Change Rate (PFT)
Humidity Ratio g Water/Kg Dry Air
Air Change, litres/second
House Number
139 101 99 32 98 108 129 56 114 110 119 20 14 43
84 1 35 96 76 3 6 86 106 131 126 95 12 127
Humidity Ratio
Air Change

FIGURE 15

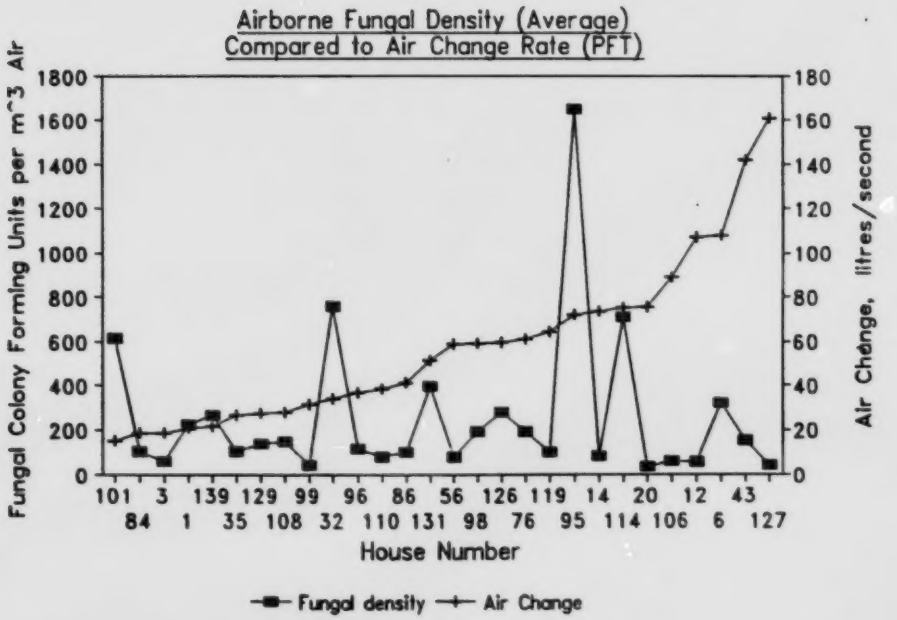

Airborne Fungal Density (Average)
Compared to Air Change Rate (PFT)
Fungal Colony Forming Units per m^3 Air
Air Change, litres/second
House Number
101 3 139 129 99 96 86 56 126 119 14 20 12 43
84 1 35 108 32 110 131 98 76 95 114 106 6 127
Fungal density
Air Change

FIGURE 16

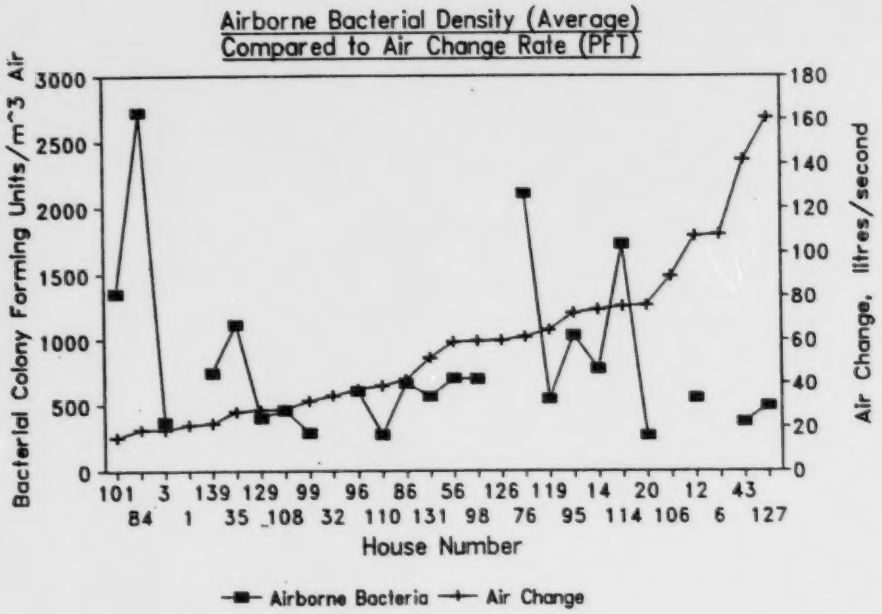
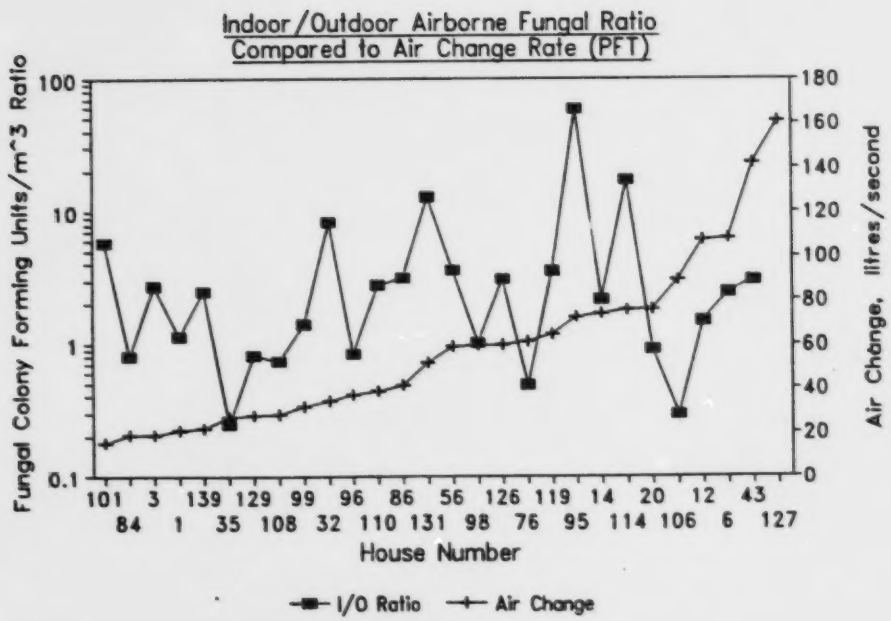


FIGURE 17



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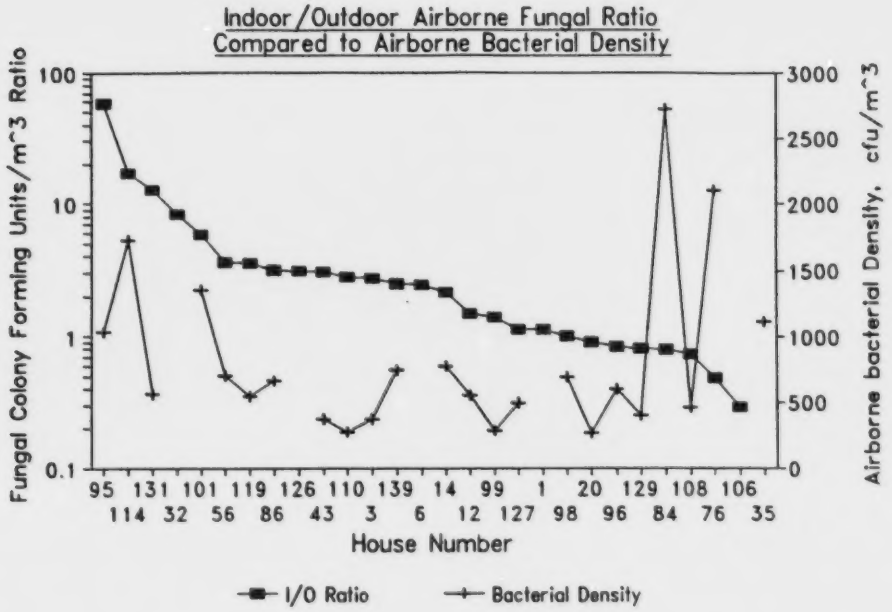

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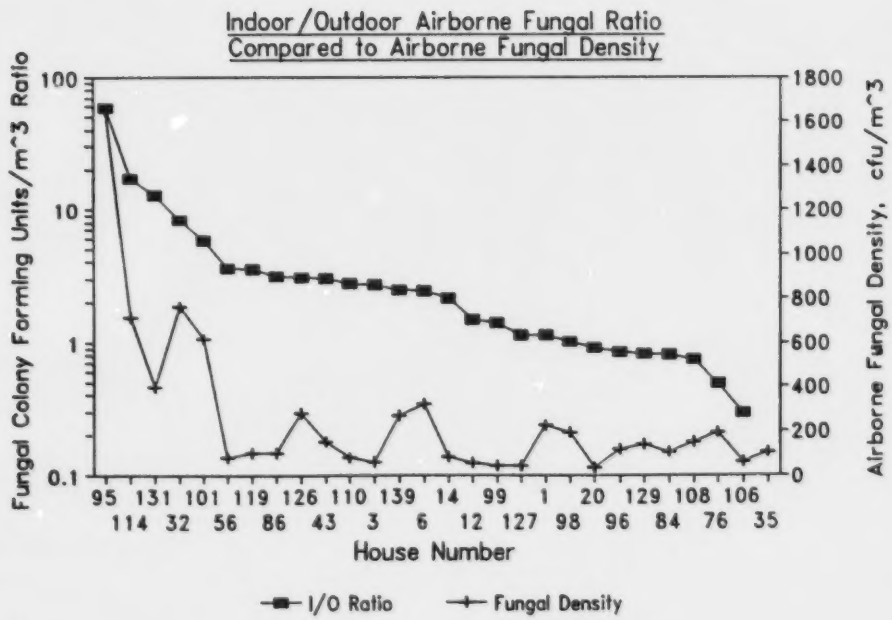

FIGURE 20

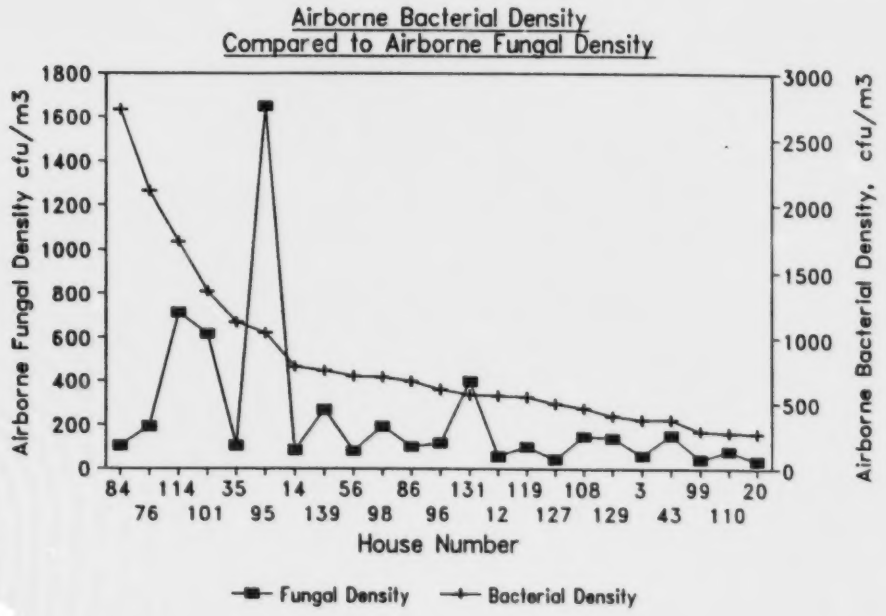

FIGURE 21

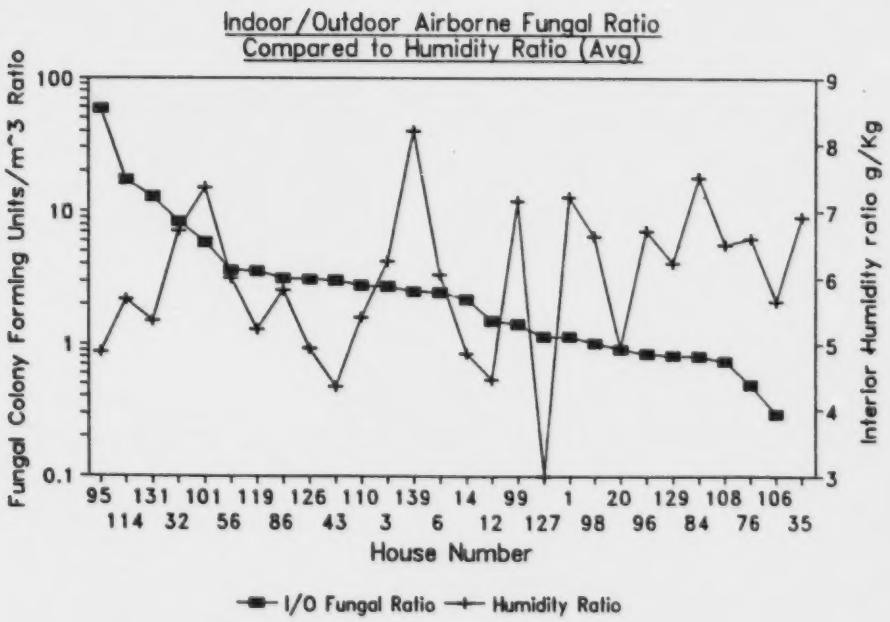

FIGURE 22

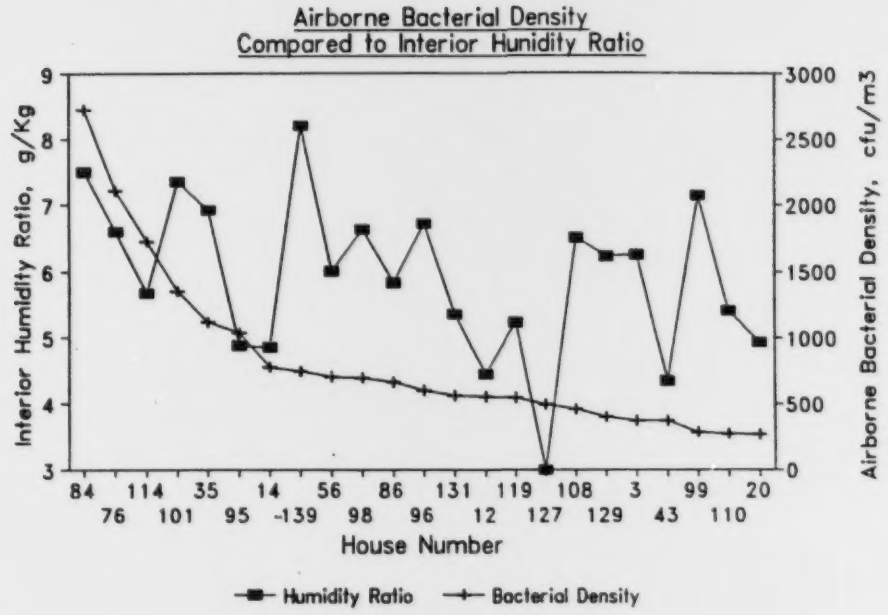

FIGURE 23

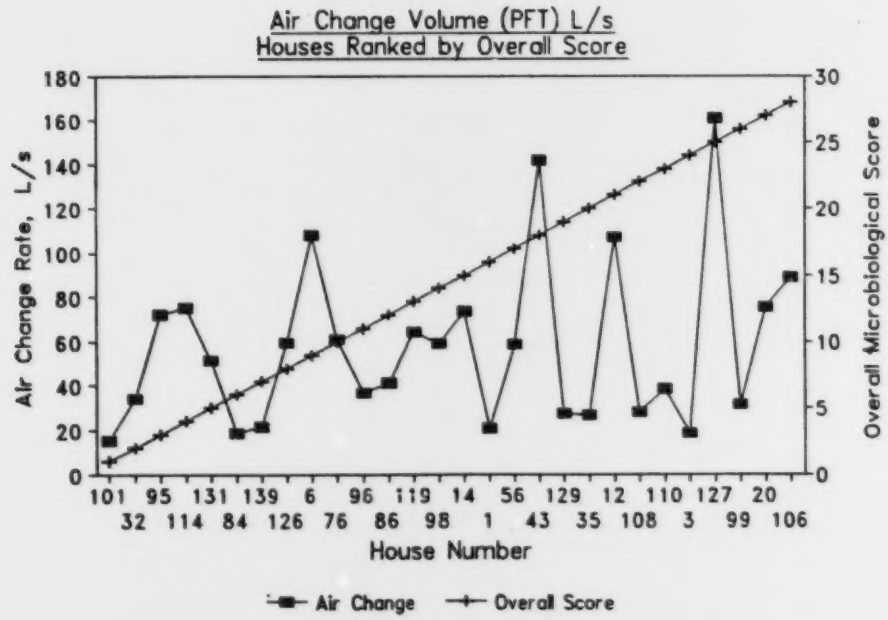

FIGURE 24

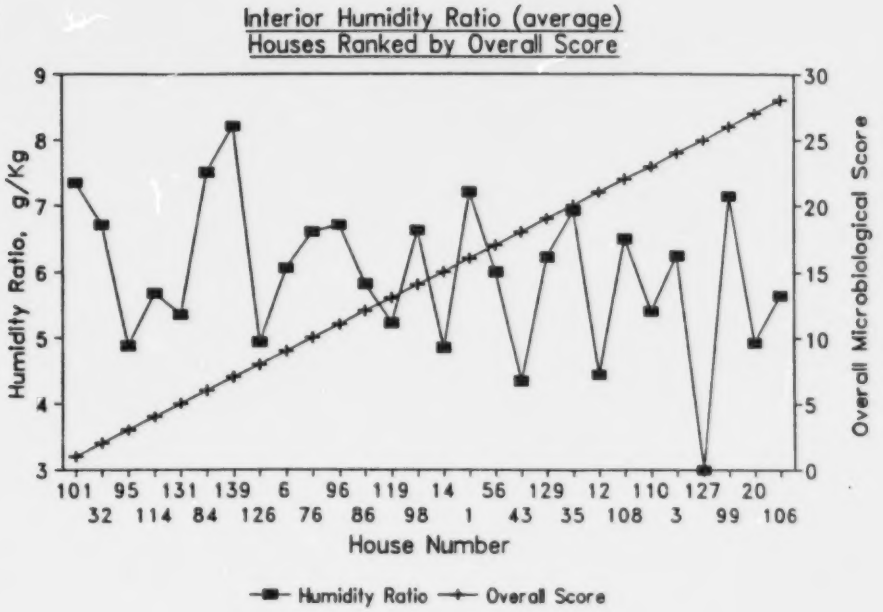

FIGURE 25

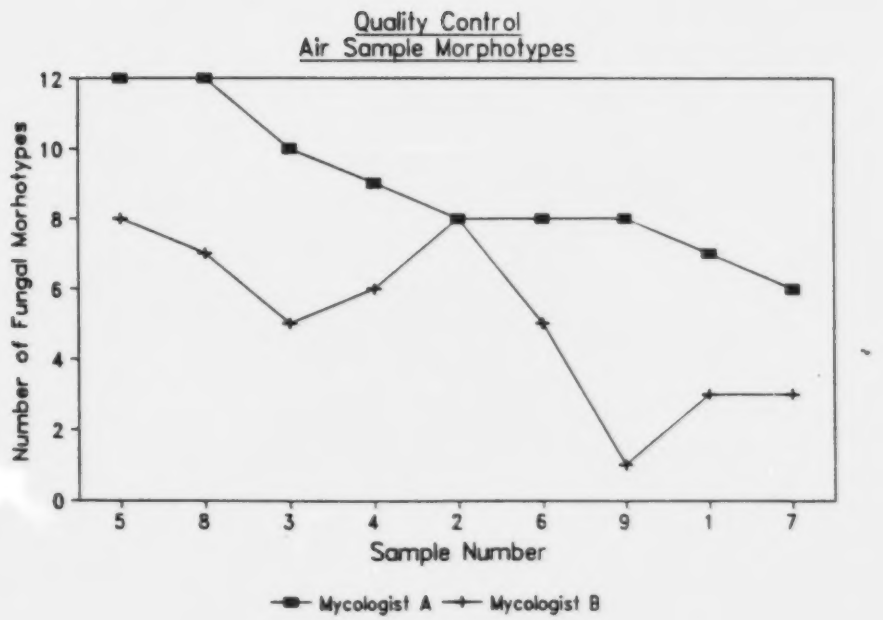

FIGURE 26

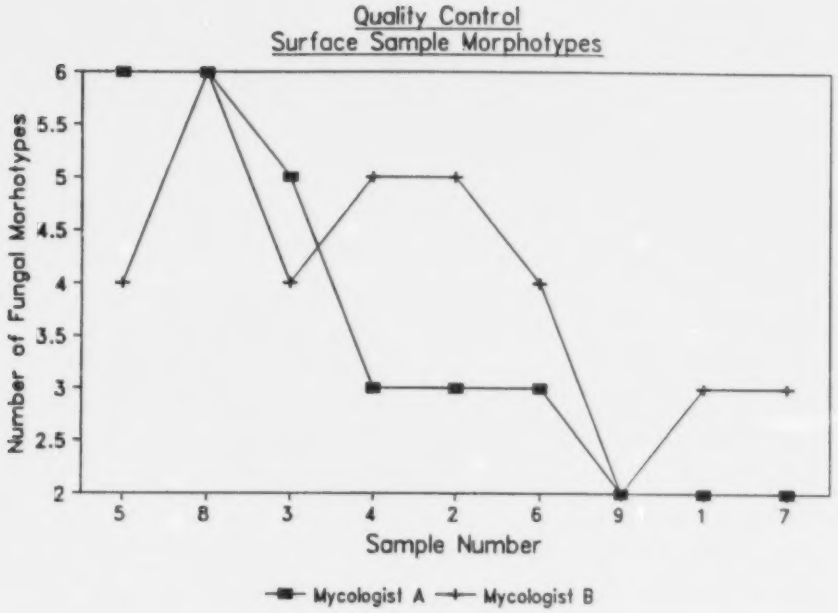

FIGURE 27

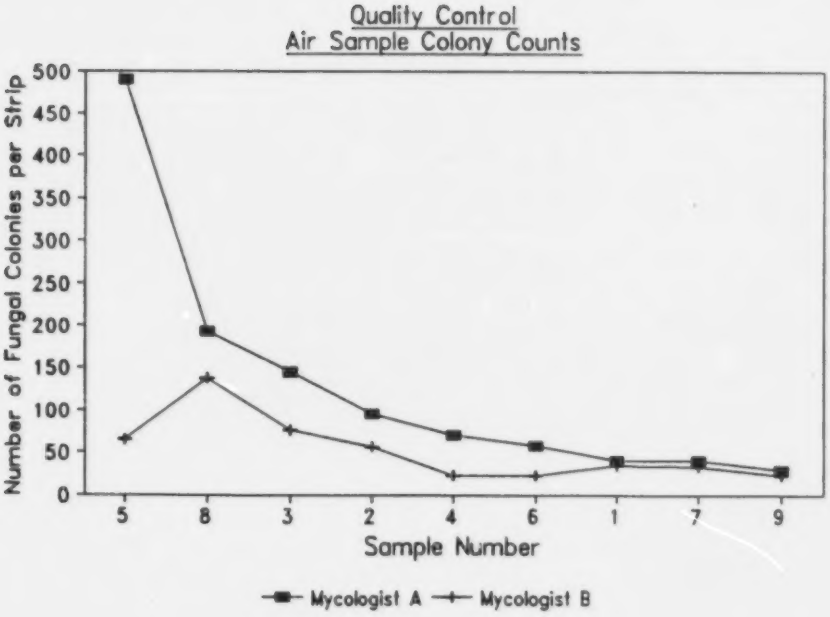

FIGURE 28

TABLE 1A
Quantitative results of Fungal and Bacterial Air Sampling

Fungal Colony Forming Units/m^3

	Kitchen	Living	Basement	Basement without #95
Minimum	6	3	19	19
Average	140	125	495	342
Standard Deviation	131	184	867	663
Maximum	566	950	4630	1531
Number	28	28	28	27

Indoor/Outdoor Fungal CFU Ratio

	Kitchen	Living	Basement	Basement without #95
Minimum	0.13:1	0.06:1	0.49:1	0.49:1
Average	2.4:1	1.8:1	11.2:1	5.50:1
Standard Deviation	3.0:1	2.0:1	31.0:1	8.41:1
Maximum	14:1	9:1	165:1	31:1
Number	28	28	28	27

Bacterial Colony Forming Units/m^3

	Kitchen	Living	Basement
Minimum	206	106	140
Average	915	705	834
Standard Deviation	890	563	706
Maximum	3906	2438	2875
Number	24	24	24

TABLE 1
Surface Sample Results Organized According to Sample Frequency

Location	Average Bacterial Count	Average Fungal Count	Number of Samples
Refrigerator Drain pan	16102412	2.0	11
Humidifier Pan	26290288	1.0	8
Window, Master bedroom	21307670	3.2	7
Window, Bathroom	3392000	2.3	6
Floor Drain	65960052	2.2	5
Bath/Shower Surround	145241200	3.2	5
Window, Child's	536250	2.3	4
Furnace Filter	2175	1.0	4
Basement Wall/Floor	11642083	0.8	4
Basement Wall	35200000	1.7	3
Window, Basement	1320000	3.0	2
Window, Other	49250000	2.5	2
Outside Closet	5000000	3.0	2
Sump Hole	30000000	3.0	2
Kitchen Sink	22058630	3.5	2
HRV Drain Pan	n/a	3.0	2
Cold Room Floor	73000000	4.0	1
Refrigerator Gasket	20	4.0	1
Attic Wood	75000	0.0	1
Range Hood Filter	2000	1.0	1
Refrigerator Drain Pan Dry	0	0.0	1
Water pipe	200	0.0	1
Window, Laundry	21000000	4.0	1
Window, Kitchen	750000	3.0	1
Master bedroom Ceiling/Wall	200000	3.0	1
Cold Room Ceiling	1000000	3.0	1
Sump Hole Water	n/a	3.0	1
Return Air Grille	50000	2.0	1
Dehumidifier Pan	210000	2.0	1
Pet Food	20000	3.0	1
Basement Soil	1500000	2.0	1

TABLE 2
Surface Sample Results Organized According to Fungal Count

Location	Average Bacterial Count	Average Fungal Count	Number of Samples
Window, Laundry	21000000	4.0	1
Cold Room Floor	73000000	4.0	1
Refrigerator Gasket	20	4.0	1
Kitchen Sink	22058630	3.5	2
Bath/Shower Surround	145241200	3.2	5
Window, Master bedroom	21307670	3.2	7
Pet Food	20000	3.0	1
Master bedroom Ceiling/Wall	200000	3.0	1
Sump Hole	30000000	3.0	2
Outside Closet	5000000	3.0	2
HRV Drain Pan	n/a	3.0	2
Cold Room Ceiling	1000000	3.0	1
Window, Basement	1320000	3.0	2
Sump Hole Water	n/a	3.0	1
Window, Kitchen	750000	3.0	1
Window, Other	49250000	2.5	2
Window, Bathroom	3392000	2.3	6
Window, Child's	536250	2.3	4
Floor Drain	65960052	2.2	5
Refrigerator Drain pan	16102412	2.0	11
Basement Soil	1500000	2.0	1
Return Air Grille	50000	2.0	1
Dehumidifier Pan	210000	2.0	1
Basement Wall	35200000	1.7	3
Humidifier Pan	26290288	1.0	8
Furnace Filter	2175	1.0	4
Range Hood Filter	2000	1.0	1
Basement Wall/Floor	11642083	0.8	4
Refrigerator Drain Pan Dry	0	0.0	1
Water pipe	200	0.0	1
Attic Wood	75000	0.0	1

TABLE 3
Surface Sample Results Organized According to Bacterial Count

Location	Average Bacterial Count	Average Fungal Count	Number of Samples
Bath/Shower Surround	145241200	3.2	5
Cold Room Floor	73000000	4.0	1
Floor Drain	65960052	2.2	5
Window, Other	49250000	2.5	2
Basement Wall	35200000	1.7	3
Sump Hole	30000000	3.0	2
Humidifier Pan	26290288	1.0	8
Kitchen Sink	22058630	3.5	2
Window, Master bedroom	21307670	3.2	7
Window, Laundry	21000000	4.0	1
Refrigerator Drain pan	16102412	2.0	11
Basement Wall/Floor	11642083	0.8	4
Outside Closet	5000000	3.0	2
Window, Bathroom	3392000	2.3	6
Basement Soil	1500000	2.0	1
Window, Basement	1320000	3.0	2
Cold Room Ceiling	1000000	3.0	1
Window, Kitchen	750000	3.0	1
Window, Child's	536250	2.3	4
Dehumidifier Pan	210000	2.0	1
Master bedroom Ceiling/Wall	200000	3.0	1
Attic Wood	75000	0.0	1
Return Air Grille	50000	2.0	1
Pet Food	20000	3.0	1
Furnace Filter	2175	1.0	4
Range Hood Filter	2000	1.0	1
Water pipe	200	0.0	1
Refrigerator Gasket	20	4.0	1
Refrigerator Drain Pan Dry	0	0.0	1
Sump Hole Water	n/a	3.0	1
HRV Drain Pan	n/a	3.0	2

TABLE 4
Microbiological Mechanisms Identified in 14 Houses with Highest Microbiological Activity

Number of Occurrences	Microbiological Mechanism
4	Low air change
4	Exposed soil
3	Hidden mould in basement construction materials
2	Water leak in basement
2	Refrigerator drain pan mould
2	Non-forced air system
2	Poor thermal break windows
2	High levels of occupation
2	Heavy drapes over window
2	Non-combustion heating
1	Portable humidifier
1	Furnace mounted humidifier mould
1	Heat recovery ventilator mould
1	Mould in attic
1	Uninsulated wall
1	Single glazed window
1	Large set-back
1	Summer condensation in basement
1	Mould on exterior surfaces
1	Insulation gaps

TABLE 5
Building Features/Observations in Houses with Higher/Lower Microbiological Activity

Building Feature	14 Houses with Highest Microbiological Activity Score	14 Houses with Lowest Microbiological Activity Score
Adjacent shrubs	0	3
Concrete block Foundation	5	5
Cast-in-place foundation	7	8
Rubble/stone foundation	2	1
Parged foundation	3	7
Foundation in good condition?	9	10
Foundation in poor condition?	5	4
Cathedral ceiling	1	0
Ceiling fans	4	3
Moisture in attic	6	3
Fungi in attic	5	4
Finished basement	8	11
Birds	2	4
Dry floor drain trap	0	1
Open sanitary drain	0	2
Raised basement floor	0	1
Carpet on concrete in basement	8	12
Crawlspace	4	2
Previous flood	4	5
Current leakage in basement	4	4
Mechanical System		
Window air conditioner	3	1
Central air conditioner	3	9
Fireplace	4	6
Wood-stove	3	5
Heat recovery ventilator	1	0
Bath fan vents into attic	3	0
Bath fan vented ok	6	5
Dryer	14	14
Dryer not vented outside	1	1
Kitchen fan recirculating	6	4
Kitchen fan vented outside	4	5
Kitchen fan vented to attic	0	1
Forced warm air heating	11	12
Base-board heating system	3	2
Filter condition good	10	3
Filter condition fair/poor	0	5
Wood primary heating	2	0
Elec./Heat-pump primary heating	4	2
Gas primary heating	6	12
Oil primary heating	2	0
Heating draft type sealed	4	3
Heating draft type induced	0	1
Heating draft type natural	10	10
Possible combustion spillage	1	0
Water heating electric	7	4
Water heating gas	7	10
Water heating draft sealed	7	4
Water heating draft induced	0	2
Water heating draft natural	6	8

cont'd.....

TABLE 5; continued
Building Features/Observations in Houses with Higher/Lower Microbiological Activity

Mechanical Feature (cont'd)	14 Houses with Highest Microbiological Activity Score	14 Houses with Lowest Microbiological Activity Score
Humidifier Furnace-drum/other	4	8
Humidifier Portable drum	2	2
Humidifier Vaporiser	1	0
Humidifier Ultrasonic/cool mist	3	3
Humidifier mouldy?	1	0
Humidifier use days/week avg.	1.64	1.21
Dehumidifier	8	10
Dehumidifier use constantly	2	1
Dehumidifier use summer	2	4
Dehumidifier mouldy?	1	0
Setback temperature yes/no	9	6
Setback total hours/day	92	49
Mould/Condensation/Other		
Mouldy ceiling	5	3
Mouldy walls	6	0
Mouldy sink overflow	0	2
Mouldy smell	7	5
Mouldy smell basement	6	0
Mouldy smell drain	0	3
Condensation on window	9	6
Condensation other	0	1
Number of plants	107	85
Attached greenhouse	0	1
Finished Basements and Dehumidification		
Finished basement	8	11
Dehumidifier	8	10
Central air conditioner	3	9
Fin.basement, with dehumidifier	6	10
Fin. basement without dehumidifier	2	1
Fin. basement with central A/C	1	7
Fin. basement without central A/C	7	4
Fin. basement with A/C and Dehumid.	0	6

TABLE 6
Isolated Predominant Fungal Species by Air and Surface Locations

Fungal Species	# of Air Samples			# of Surface Samples		
	Base	Kitch	Living	Base	Kitch	Living
Acremonium alternatum				1	1	1
Alternaria alternata	2	1				
Aspergillus candidus						
Aspergillus clavatus	1					
Aspergillus niger	1					
Aspergillus ornatus	1					1
Aspergillus terreus				1		
Aureobasidium pullulans	1					1
Cladosporium cladosporoides	2			1	1	2
Cladosporium herbarum	2	2	1	3	2	3
Cryptococcus albidis						1
Drechslera dematioidea						1
Fusarium aqueductum					1	
Penicillium brevicompactum						1
Penicillium camemberti		1				
Penicillium chrysogenum	2					
Penicillium decumbens				1		
Penicillium funiculosum	1					
Penicillium herquei			1			
Penicillium nigricans	1					
Penicillium purpurogenum		1				
Penicillium restrictum	1		1			
Penicillium rugulosum	2					
Phoma sp.				1		
Rhizopus sp.	2					
Rhodotorula glutinis				1		
Rhodotorula minuta						
Rhodotorula rubra		1		1		
Stemphilium botryosum	1			1		

TABLE 6A
Isolated Predominant Fungal Species and Reported Toxic Potential

Fungal Species	# of Air and Surface Samples		
	Total	"Toxigenic"[1]	"Myco-toxin Producing"[2]
Acremonium alternatum	3	3	3
Alternaria alternata	3		
Aspergillus candidus			
Aspergillus clavatus	1		
Aspergillus niger	1	1	
Aspergillus ornatus	2		1
Aspergillus terreus	1		
Aureobasidium pullulans	2		
Cladosporium cladosporoides	6	6	6
Cladosporium herbarum	13	13	
Cryptococcus albidis	1		
Drechslera dematioidea	1		
Fusarium aqueductum	1		
Penicillium brevicompactum	1	1	1
Penicillium camemberti	1		
Penicillium chrysogenum	2	2	
Penicillium decumbens	2	1	1
Penicillium funiculosum	1		
Penicillium herquei	1		
Penicillium nigricans	1		
Penicillium purpurogenum	1		
Penicillium restrictum	2		
Penicillium rugulosum	2		
Phoma sp.	1		1
Rhizopus sp.	2		2
Rhodotorula glutinis	1		
Rhodotorula minuta			
Rhodotorula rubra	2		
Stemphilium botryosum	2		
Totals:	56	27	15

1-"Reported to be Toxigenic" according to Table I of Reference 6
2-Identified as a "Mycotoxin Producer" according to Table II of Reference 6

TABLE 7
Isolated Predominant Bacterial Species by Location

Bacterial Species	Number of Air Samples			Number of Surface Samples		
	Base	Kitch	Living	Base	Kitch	Living
Acinetobacter geno sp.9	1			1		
Acinetobacter lwoffi						1
Alcaligenes paradoxus				1		
Arthrobacter oxydans			1			
Aureobacterium sp.				1	1	
Bacillus cereus	1			1		
Bacillus circulans					1	2
Bacillus megaterium				1	1	1
Bacillus sphericus	1					
Clavibacterium michiganense						2
Corynebacterium sp. (Gp.ANF1)		1				1
Corynebacterium xerosis				1		
Flavobacterium sp.						
Klebsiella oxytoca						1
Methylobacterium sp.						1
Micrococcus luteus		2	2			1
Pseudomonas aureofaciens						1
Pseudomonas fluorescens				3		1
Pseudomonas vesicularis				1		
Rhodococcus sp.		1				
Staph-cohnii			1			
Staph. haemolyticus	1		3			
Staph. saprophyticus		2				
Staph. warneri	1	1	2			
Staph. xylosus	1					

TABLE 8
Quality Control Sample Count Comparison

Sample Code	Fungal Colony Counts per Strip		Location	Fungal Morpho-types in Sample		Sample Number
	Lab A	Lab B		Lab A	Lab B	
A321/3	41	34	Outside air	7	3	1
A324/6	95	56	Kitchen air	8	8	2
A327/9	145	77	Living air	10	5	3
A3210/12	70	23	Bedroom air	9	6	4
A3213/15	490	65	Basement air	12	8	5
A1261/3	58	23	Kitchen air	8	5	6
A1264/6	41	33	Living air	6	3	7
A1267/9	192	138	Basement air	12	7	8
A12610/12	29	23	Outside air	8	1	9
S321	Surface		Window	6	6	10
S322	Surface		Closet	3	5	11
S323	Surface		Ref Pan	3	4	12
S324	Surface		DeHumidifier	2	3	13
S1261	Surface		Sump	3	5	14
S1262	Surface		HRV Pan	2	3	15
S1263	Surface		HRV Pan	6	4	16
S1264	Surface		Ref Pan	2	2	17
S1265	Surface		Ref Gasket	5	4	18

TABLE 9
Quality Control Identification Comparison

	Mycologist A	Mycologist B	
Sample #:	3	3	
Sample Code:	A327	A329	
Location:	Living Air	Living Air	
Colonies:	145	77	
Morphotypes:	10	5	
Species 1:	Penicillium herquei	Penicillium sp.	55
Species 2:	Cladosporium sp.	Cladosporium sp.	17
Species 3:	Alternaria sp.	Alternaria sp.	3
Species 4:		Aspergillus sp.	1
Species 5:		Ulocladium sp.	1
Sample #:	4	4	
Sample Code:	A3210	A3212	
Location:	Bedroom Air	Bedroom Air	
Colonies:	70	23	
Morphotypes:	9	6	
Species 1:	Rhodotorula minuta	Penicillium sp.	20
Species 2:	Penicillium sp.	Cladosporium sp.	16
Species 3:	Mucor sp.	Aureobasidium sp.	1
Species 4:		Botrytis sp.	1
Species 5:		Geomyces sp.	1
Species 6:		Scopulariopsis sp.	1
Species 6:		Sterile colony	1
Sample #:	5	5	
Sample Code:	A3213	A3215	
Location:	Basement Air	Basement Air	
Colonies:	490	65	
Morphotypes:	12	8	
Species 1:	Penicillium rugulosum	Penicillium sp.	37
Species 2:	Cladosporium sp.	Cladosporium sp.	18
Species 3:	Alternaria sp.	Epicoccum sp.	3
Species 4:		Chaetomium sp.	2
Species 5:		Eurotium sp.	2
Species 6:		Rhizopus nigricans	1
Species 7:		Aspergillus sp.	1
Species 8:		Beauveria bassiana	1
Sample #:	8	8	
Sample Code:	A1267	A1269	Sub-
Location:	Basement Air	Basement Air	count
Colonies:	192	138	
Morphotypes:	12	7	
Species 1:	Penicillium chrysogenum	Penicillium sp.	64
Species 2:	Rhizopus sp.	Cladosporium sp.	38
Species 3:	Aspergillus sp.	Aspergillus sp.	18
Species 4:	Mucor sp.	Alternaria sp.	10
Species 5:	Alternaria sp.	Mucor sp.	5
Species 6:		Epicoccum sp.	2
Species 7:		Rhizopus sp.	1

.....cont'd

TABLE 9 cont'd
Quality Control Identification Comparison

	Mycologist A	Mycologist B
Sample #:	11	11
Sample Code:	S322	S322
Location:	Closet Wall	Closet Wall
Colonies:	60	40.25*
Morphotypes	3	5
Species 1:	Aspergillus ornatus	Various Yeasts
Species 2:		Aspergillus sp.
Species 3;		Penicillium sp.
Species 4:		Cladosporium sp.
Species 5;		Aureobasidium sp.
Sample #:	15	15
Sample Code:	S1262	S1262
Location:	HRV Drain Pan	HRV Drain Pan
Colonies:	20	11400*
Morphotypes	2	3
Species 1:	Cryptococcus albidis var. albi	Various Yeasts
Species 2:		Aureobasidium pullulans
Species 3:		Aspergillus versicolour
Sample #:	17	17
Sample Code:	S1264	S1264
Location:	Ref Drain Pan	Ref Drain Pan
Colonies:	200	53400000*
Morphotypes	2	2
Species 1:	Aureobasidium pullulans	Yeasts (Rhodotorula?)
Species 2:	Rhodotorula rubra	Aureobasidium pullulans

* Note: Colony counts are not comparable between mycologists due to differences in counting methods.
In addition, sample counts may vary due to the sampling method, which consisted of individual samples from a common site, rather than a single sample, homogenized and separated.

TABLE 10
Detailed Identification, Mycologist B only, House 32

AIR SAMPLES	CFU/m³	SURFACE SAMPLES	CPU
A323 Outside air			
Cladosporium sp.	78		
Alternaria sp.	3		
Epicoccum sp.	3		
A326 Kitchen air		**S323 Refrigerator Drain pan**	
Penicillium sp.	106	Various Yeasts	5850
Cladosporium sp.	41	Aspergillus sp.	400
Aspergillus sp.	9	Penicillium sp.	1000
Epicoccum sp.	6	Aureobasidium sp.	150
Fusarium sp.	3		
Ulocladium sp.	3		
Acremonium sp.	3		
Alternaria sp.	3		
A329 Living Room air			
Penicillium sp.	172		
Cladosporium sp.	53		
Alternaria sp.	9		
Aspergillus sp.	3		
Ulocladium sp.	3		
A3212 Bedroom air		**S321 Bedroom Window**	
Penicillium aurantiogriseum	25	Various Yeasts	1650000
Penicillium brevicompactum[1,2]	6	Aureobasidium pullulans	750000
Penicillium janthinellum[1]	6	Alternaria alternata[1,2]	100000
Penicillium simplissimum	3	Cladosporium cladosporoides[1,2]	100000
Penicillium spinulosum	22	Cladosporium sphaerosperum	100000
Cladosporium cladosporioides[1,2]	38	Ulocladium chartarum	100000
Cladosporium sphaerospermum	13		
Aureobasidium pullulans	3	**S322 Closet (Bedroom)**	
Botrytis cinerea	3	Various Yeasts	3110000
Geomyces pannorus	3	Aspergillus sp.	620000
Scopulariopsis fusca	3	Penicillium sp.	315000
Sterile colony	3	Cladosporium sp.	75000
		Aureobasidium sp.	5000
A3215 Basement air			
Penicillium adamezioides	3	**S324 Dehumidifier Pan**	
Penicillium aurantiogriseum	6	Various Yeasts	500000
Penicillium brevicompactum[1,2]	28	Aureobasidium sp.	18500
Penicillium implicatum	3	Penicillium sp.	500
Penicillium janthinellum[1]	3		
Penicillium simplissimum	22		
Penicillium spinulosum	50		
Cladosporium cladosporioides[1,2]	9		
Cladosporium sphaerospermum	47		
Epicoccum nigrum	9		
Chaetomium globosum	3		
Chaetomium sp.	3		
Eurotium repens	6		
Rhizopus nigricans	3		
Aspergillus versicolour[1]	3		
Beauveria bassiana	3		

1-"Reported to be Toxigenic" according to Table I of Reference 6
2-Identified as a "Mycotoxin Producer" according to Table II of Reference 6

TABLE 11
Detailed Identification, Mycologist B only, House 126

AIR SAMPLES	CFU/m³
A12612	
Outside air	
Cladosporium sp.	66
A1263	
Kitchen Air	
Aspergillus versicolour[1,2]	28
Penicillium aurantiogriseum	6
Penicillium chrysogenum[1]	3
Penicillium janthinellum[1]	3
Penicillium paxilli	3
Penicillium spinulosum	3
Cladosporium sphaerospermum	6
C. cladosporioides[1,2]	10
Scopulariopsis fusca	6
Aureobasidium pullulans[1]	3
A1266	
Living Room air	
Penicillium sp.	47
Aspergillus sp.	38
Cladosporium sp.	19
A1269	
Basement Air	
Penicillium sp.	200
Cladosporium sp.	119
Aspergillus sp.	56
Alternaria sp.	31
Mucor sp.	16
Epicoccum sp.	6

SURFACE SAMPLES	CFU
S1264	
Refrigerator Drain Pan	
Various Yeasts	48000000
Aureobasidium pullulans[1]	5400000
S1262	
HRV Pan	
Various Yeasts	9900
Aureobasidium pullulans[1]	1350
Aspergillus versicolour[1,2]	150
S1263	
HRV Drain Pan	
Various Yeasts	1600000
Aureobasidium sp.	45000
Cladosporium sp.	500
Penicillium sp.	500
S1261	
Sump Hole Water	
Various Yeasts	220
Penicillium sp.	140
Aspergillus sp.	15
Aureobasidium sp.	10
Mucor sp.	0.5
S1265	
Freezer Gasket	
Aureobasidium sp.	4850000
Various Yeasts	750000
Cladosporium sp.	600000
Penicillium sp.	50000

1-"Reported to be Toxigenic" according to Table I of Reference 6
2-Identified as a "Mycotoxin Producer" according to Table II of Reference 6

APPENDIX A

PROTOCOL

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PROTOCOL

1. Site Selection

a. Homes were selected from a list of 141 houses in Tillsonburg, Ontario. These houses have previously had a questionnaire completed by the parent or guardian of a school child. The questionnaire responses contain data about the occupant's health, the house mechanical system, house dampness and the presence or absence of mould and mildew.

b. A letter of introduction was provided by Health and Welfare Canada (HWC). printed on HWC letterhead. The text of this letter is contained in appendix A. The letter referred the to local CMHC office and invitation to call to verify the legitimacy of the testing agent. One letter for each of the houses was provided. The letter was addressed to the questionnaire respondent. In many instances the addressee was not the current occupant of the house, as the questionnaire was administered in 1988.

In cases where the current occupant did not participate in the original questionnaire, very little success in obtaining testing permission was obtained.

c. The testing Agent (TA) mailed letters on a timed schedule,beginning with an initial group of 10 letters. Mailed letters were pre-screened based on the availability of telephone numbers which were obtained from the telephone directory.

d. One week following the mailing date of the letters, the addressee was telephoned and a request for site visit was made. If successful, a time and date for house visit was set. Visits were carried out during the day and evening.

e. The pace of house visits was two or three per day, but not more than four per week, conducted on Mondays and Tuesdays. This schedule was struck in recognition of the limited capacity of the microbiological sample analysis laboratory.

f. Successive groups of letters were released by the TA depending on the success rate of telephone contacts and according to the project schedule.

g. Site visits began January 15th, and concluded March 25th.

2. Outdoor Measurements

Prior to entry to the house, the following measurements were recorded:

i. Outdoor temperature (dry-bulb)

ii. If the outdoor temperature was above freezing; wet-bulb temperature.

iii. Outdoor wind-speed on days when Blower-Door testing was done. (if the wind was other than "very light")

3. Occupant Information

Upon entry into the house, one of the team members engaged the occupant with the following activities:

a. Explain the general activities that will be taking place during the visit. The purpose of the testing was explained in a manner concordant with the letter of introduction provided by HWC. The purpose of the different testing devices and receivers etc was also explained.

b. The house occupant was offered access to the results of testing, if access to such results was requested the occupant was given a form letter to be completed with his/her name and address and the house identification code. This letter was addressed to the author of the original, introductory letter and a stamped, pre-addressed envelope was provided.

All occupants requested access to the results of testing for their houses.

c. Administration of the Volatile Organic Compound Questionnaire. In some cases the VOC questionnaire was not available at the time of visit, but was completed at a later date, by telephone.

d. Set a mutually convenient time to return to pick up the Perflourocarbon (PFT) emitters and receivers.

e. Explain the HWC Questionnaire and agree on a time when the HWC Questionnaire would be completed. Usually the questionnaire was completed on the day of visit, however in some cases, up to 1 month was required to allow for completion. In all cases. the questionnaires were collected personally by TA personnel.

The questionnaire was requested to be completed by the original respondent if at all possible. If the original respondent was not available, the responsible adult "care-giver" of the household was requested as a preference.

4. Building Information

The following physical information was recorded:

a. All room sizes with a general sketch of the floor plans. Window and door locations but not sizes.

b. Floor to ceiling heights on all levels.

c. The following building features were be described according to type and condition. Features or conditions which would lead to the water entry, dampness or mould and mildew formation were emphasized.

(1) Framing
(2) exterior wall finish
(3) interior wall finish
(4) window type
(5) attic insulation
(6) attic ventilation
(7) roofing
(8) foundation exterior
(9) foundation interior

d. The following checklist was completed with respect to potential sources of microbial contamination;

(1) Birds or bats near air intake?
(2) Birds or bats in attic or basement?
(3) Faulty floor drain traps? Dry?
(4) Toilet vented into building?
(5) Contaminated obviously dirty humidifier?
(6) Dehumidifier over floor drain in basement?
(7) Earthen floor in basement?
(8) Attached crawl space?
(9) Fungal growth on ceiling tiles, walls, windows etc?
(10) Strong evidence of mouldy smells?
(11) Many plants, attached greenhouse?
(12) Condensation on windows?
(13) Raised basement floors?
(14) Carpet on concrete
(15) Window air conditioner-contaminated filter?
(16) Dirty HRV filters?
(17) Closets on outside walls?

(18) Dirty filter in house heating/air-conditioning system?
(19) Fungal growth in attic?
(20) Landscaping that directs water into house?
(21) Trees and shrubs against house?
(22) Sink overflow?

e. The presence of any thermal bridges in the structure was be noted and described. If appropriate (mould/mildew present) a photograph was be taken.

f. Where appropriate, and in particular for non-window thermal bridges where dampness or accumulated moisture is present a surface temperature measurement was be obtained.

g. The presence of any other mould/mildew sites was noted and photographed if appropriate.

h. Significant building features and anomalies were photographed if deemed appropriate by field personnel.

5. Indoor Temperature Measurements

a. The air temperature (dry-bulb) was measured on the main floor and in the basement at a central location.

b. Wet-bulb temperatures were also measured at the same time as the air-temperature measurement, and in the same locations. Relative humidity and humidity ratio's were derived from these measurements.

c. Air temperature was measured in the immediate vicinity of the main house heating control thermostat, and at the same time, the set point of the thermostat, and the position of the thermostat's temperature indicator (if any) was noted.

6. Blower Door Test

a. The blower door test was performed with the house prepared by sealing all combustion device flues and combustion air inlets for fuel fired appliances. This corresponds to schedule "C" of the "1989 Survey of Airtightness of New, Detached, Merchant Builder Homes" (ref 1).

b. Measurement procedure and reported results are according to CGSB 149.10.

7. PFT Infiltration Test

a. Single-zone receivers and emitters (PMCP-8 "red") were placed according to the supplier's (NAHB Research) instructions.

b. Receivers were deployed at the rate of approximately one per 500 ft^2 of building floor are (including the basement).

c. Emitters were deployed at least 16 hours prior to the uncapping of receivers. This procedure corresponds approximately with the 24-hour re-visit sequence required for the VOC samplers. In the majority of cases uncapping was done by TA personnel, except for several houses were the homeowner carried out the uncapping on an agreed schedule.

d. Receivers and emitters were left in place for a periods ranging from one week to 5 weeks, with the average being 2 weeks.

e. As much as practical receivers and emitters were shipped, stored and handled separately.

8. Microbiological Air Sampling

a. The samples were taken with Biotest R.C.S. Centrifugal Air Sampler which samples at a rate of 40 litres/minute.

b. The sampling time (a setting on the RCS sampler) was set at 8 minutes for all samples.

c. Samples were obtained at a height of about 5 feet (1.5 m) above the floor with the sampler mounted on a tripod and stationary. Generally, the fungal and bacterial air strips were exposed at the same time in each location.

d. The interior of the sampling drum of the sampler was sterilized using isopropyl alcohol.:

(1) prior to sampling in a house.
(2) before and after sampling in the basement

If the VOC samplers were open, sterilization was carried out of doors.

e. Sample strips were supplied in individual, air-tight "blisterpak" packages. Blank strips which are not airtight prior to sampling were discarded.

f. Sampling strips were stored at 8 to 15°C away from light prior to use.

g. Three locations per house were sampled as follows:

(1) Air-samples were taken in the kitchen and living areas of each house.

(2) Two locations corresponding to the kitchen and main living area were sampled with one each of each type of sample strip. (total of four samples, two each of F and B types)

(3) All of the house windows were closed during the these tests.

(4) Air samples were taken in the basement area.

(5) Two samples, one each of type F and B were taken at a location in the approximate centre of the basement area. If the basement is sub-divided, preference was given to that area which is largest, has air circulation in common with the rest of the house, and has exposure to outside walls.

(6) The basement air samples were conducted at the same time as the "Blower Door" test, with the blower-door operating in "depressurization" mode. If the blower-door test was completed prior to the end of the air-sampling period, the blower-door was operated at a depressurization level of 20 pa for the balance of the air-sampling duration.

h. Outdoor air samples using type "F" media only were obtained on those days when indoor samples were being taken. In general one sample per day was obtained, however where tested houses were widely separated additional outdoor samples were obtained.

i. After sampling, exposed sample strips were returned to their original "bubble-pak" carriers, sealed with masking tape to preserve air-tightness and labelled.

j. Labels were applied to the sample strip containers so as not to obstruct the view of the sample medium.

k. The label contained at least the sample control code, (which contains the house #), date, time of day and sampling duration. Sample location was not marked except for outside samples (Outside samples received somewhat different analysis).

l. If, during sampling, a strip became contaminated by touching the technician's hands or other objects, the strip was discarded and the test repeated.

m. See "Sample Transport" for further handling protocol.

9. Sample Transport

a. Sealed, exposed samples were stored in a disposable styrofoam container at room temperature, together with the samples from other locations and houses, for up to two days prior to shipping to the analysis laboratory.

b. Such containers were packed in a cardboard box and shipped by "next day" courier to the laboratory. The time between sampling and arrival at the lab did not exceed 48 hours in most cases and did not exceed 96 hours in the extreme case. The samples were not exposed to freezing temperatures.

10. Air-Sample Analysis

a. Two types of sample-strips were used. Type "F" sample strips were prepared with a medium suitable for fungal sampling. Type "B" strips were prepared with a medium suitable for bacterial sampling.

b. Type "F" medium was Rose-Bengal-Streptomycin Agar (Biotest HS; Art. No. 941200).

c. Type "B" medium was Trypticase Soy Agar strips. (Biotest GK-A; Art No. 941100).

d. Type "F" (fungal) samples were be analyzed quantitatively as follows:

(1) Strips were incubated for ten days at 25°C.

(2) Colony counts were taken daily commencing at day two. Counts which were not necessarily highest at the end of the incubation period because of overgrowth by other colonies were recorded as the highest number obtained over the period in which they were counted.

(3) The final count (or highest count as the case may be was translated into Colony Forming Units (CFU) per cubic meter using the following equation, based on the normal airflow through the sampler of 40 L/min:

$$CFU/m^3 = \frac{\frac{1000\ L/m^3 \times \text{Colony Counts}}{40\ L/min}}{\text{Sampling Time (min)}}$$

(The above equation and counting method is from "Determination of Fungal Propagules in Indoor Air" (ref 2))

e. Type "B" (bacterial) samples were incubated for 7 days at 30°C and counted daily. Airborne concentrations were expressed in the same manner as for fungi, above.

f. Type "F" samples were further analyzed quantitatively by recording the number of different colonial morphotypes observed.

g. From the type "F" (fungal) sample strips, the colonial morphotype occurring with the greatest frequency overall on the three strips from each house was removed, cultured on Rose Bengal Malt Agar for purity at 25°C and then subcultured onto a Sabouraud Agar slope in a screw-cap bottle, incubated until growth was well established and then stored at 4°C for later identification.

Identification of the fungal samples so isolated was carried out with slide culture using Sabouraud Agar. Microscopic examination of the cultures was made daily and when suitable sporulation had taken place, the coverslip was removed, stained with lactophenol cotton blue and cultural characteristics observed and classified using various taxonomic keys.

h. From the type "B" (bacterial) strips, the colonial morphotype occurring with the greatest frequency overall on the three strips from each house was subcultured and identified as to species and genus as far as possible by observed morphology, gram staining, biochemical characteristics by biochemical tests appropriate to the class and by cell membrane fatty acid profile using MIDI chromatographical system.

i. The individual sample from which the most predominant species were isolated was recorded. In most but not all cases this was the sample with the highest numerical count.

j. Outdoor air sample strips were analyzed quantitatively only, by colony count. No morphological or speciation was conducted.

11. Microbiological Surface Sampling

a. Surface-samples were taken in three locations in each house.

b. The location of each surface sample was be recorded and if deemed appropriate by the field personnel, a photograph of the sample site was be taken.

c. Locations from which samples were taken were selected by the field personnel as those most likely to harbour fungal/bacterial growth and included:

- recirculating kitchen range hoods
- exterior wall closets, behind furniture
- refrigerator condensing coils
- refrigerator defrost drain pans
- ducts withdrawing air from areas not separated from cooking appliances
- humidifier trays (portable and fixed)
- dehumidifiers
- obvious mould growth in locations such as:
- sink overflows
- bath/tub surrounds
- damp areas in basement
- around floor drain in basement.

d. Samples were taken by:

i. In the case of dry samples: scraping the sample matter with a sharp-edged instrument which had been previously sterilized by wiping with isopropyl alcohol.

ii. In the case of liquid samples, dipping a disposable test-tube into the liquid.

iii. In the case of moist samples, scraping the sample with a calcium-alginate swab until the swab is mostly covered with the sample material.

e. The sample matter (including swab in some cases) was transferred to an air tight, disposable test-tube. The test tube will be secured in a plastic zip-loc bag and labelled. The label contained at least the sample control code, house number and date. Location descriptions were recorded separately.

f. Bagged swabs were transported to the lab in the same container with the air sample strips. See "Sample Transport" above.

12. Surface Sample Analysis

a. The calcium alginate swabs were suspended in a measured 5.0 ul of Calgon Ringer Solution, which dissolves calcium alginate. Measured dilutions at 1/100 and 1/10,000 of the initial suspensions were made. Of each suspension, 0.1 ml was pipetted onto Trypticase Soy Agar, spread and subsequently incubated at 30°C for bacteria and onto Rose Bengal Malt Agar, spread and subsequently incubated at 25°C for fungi.

b. For dry material scrapings, an amount of material that would approximate that which would be picked up by a swab was used as the basic sample quantity in order to achieve a roughly quantitative equivalency to the swab-samples.

c. For liquid samples, one ml of liquid was used as the basic sample quantity.

d. Fungal quantitative analysis was assigned a symbol-scale as follows:

"0" No colonies observed

"1" A few colonies on the undiluted sample

"2" Moderate colonies on the undiluted sample and a few colonies on the 1/100 dilution.

"3" Moderate numbers on the 1/100 sample with a few colonies on the 1/10,000 dilution.

"4" Moderate numbers on the 1/10,000 sample

e. Bacterial quantitative levels were recorded as number of colonies per swab, or number of colonies per ml of liquid, depending on the type of original sample being analyzed.

f. From each set of three samples, the most predominant species of bacterium and the most predominant species of fungus was isolated and identified to species in a fashion similar to the procedure described in 11. Air Sample Analysis above.

13. Temperature and Humidity measurements:

a. Inside temperature humidity with sling psychrometer, that is dry bulb and wet-bulb temperatures will be measured.

b. Outside temperature was measured with a digital RTD temperature measuring device if below 0°C and with a sling-mounted mercury thermometer if above 0°C.

c. Surface temperatures were measured with a digital RTD temperature measuring device equipped with an aluminum surface-temperature probe.

House Number 1

Ranking:

Humidity;	4	(lowest=most humid)
Air Change;	4	(lowest=least air change)
Airborne Fungi	9	(lowest=most fungi)
I/O Fungi ratio	19	(lowest=highest ratio)
Airborne Bacterium;	n/a	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	16	(lowest=most microbiological activity)

Notes:

1. Older home with new addition used as hair dressing salon.
2. Basement single glazed windows have significant mould
3. Front master-bedroom windows and ceiling corner have mould growth, possibly related to use of portable humidifier.
4. Home has recent induced draft water heater and furnace, which may contribute to low average air-change.
5. At 21 l/s, 0.207 ACH the ventilation rate is less than recommended minimums.

Mechanisms:

1. Low air change rates result in somewhat higher overall humidity.
2. Single-glazed windows in basement result in local condensation in cold weather and subsequent mould growth.
3. Use of a portable humidifier may contribute to mould growth in the master bedroom area.

House Number 3

Ranking:

Humidity;	12	(lowest=most humid)
Air Change;	3	(lowest=least air change)
Airborne Fungi	23	(lowest=most fungi)
I/O Fungi ratio	12	(lowest=highest ratio)
Airborne Bacterium;	19	(lowest=most bacterium)
Subjective Mouldiness;	10	(lowest=most mouldy)
Overall Mouldiness;	24	(lowest=most microbiological activity)

Notes:

1. At 19 l/s, 0.168 ACH the ventilation rate is lower than recommended minimums

2. Humidity and subjective mouldiness are substantially less than would be expected by air change rate.

3. Portable humidifier used only occasionally

4. Refrigerator has pan located on top of condenser, dry no growth at all.

5. There are 3 occupants in this house.

Mechanisms:

1. Low rates of Air Change do not appear to result in excessive mouldiness.

House Number 6

Ranking:

Humidity;	14	(lowest=most humid)
Air Change;	26	(lowest=least air change)
Airborne Fungi	6	(lowest=most fungi)
I/O Fungi ratio	14	(lowest=highest ratio)
Airborne Bacterium;	n/a	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	9	(lowest=most microbiological activity)

Notes:

1. Basement leaks in the spring most years

2. Bath fan is vented into attic

3. Attic (walk-up type) has substantial moisture/wetness damage with sections of rotten wood. Cause is more likely leakage than condensation.

4. Bedroom windows have substantial mould growth attributable to heavy curtains which lower window surface temperatures.

5. Small crawlspace with soil floor

Mechanisms:

1. Mould growth is directly attributable to the heavy curtains which are used on bedroom windows.

2. Some fungal activity may be attributable to wetness in attic due to leakage.

3. Some fungal activity attributed to basement dampness and soil floor.

House Number 12

Ranking:

Humidity;	26	(lowest=most humid)
Air Change;	25	(lowest=least air change)
Airborne Fungi	25	(lowest=most fungi)
I/O Fungi ratio	16	(lowest=highest ratio)
Airborne Bacterium;	14	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	21	(lowest=most microbiological activity)

Notes:

1. Some mould on siding where shaded by tree.
2. Basement drain trap has no primer, plugs often, smells bad.
3. Sanitary drain has leaky joint over freezer.
4. Basement shows efflorescence from water entry/evaporation.
5. Pet parrot, loose in living room often.

Mechanisms:

1. Although there is a potential mechanism for the production of fungi and bacterium (the drains) levels are not elevated. This may be attributable in part to the high levels of air change which maintain a relatively dry environment.

House Number 14

Ranking:

Humidity;	25	(lowest=most humid)
Air Change;	21	(lowest=least air change)
Airborne Fungi	20	(lowest=most fungi)
I/O Fungi ratio	15	(lowest=highest ratio)
Airborne Bacterium;	7	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	15	(lowest=most microbiological activity)

Notes:

1. Basement floor drain under raised plywood floor, trap with water but smells bad.

2. Sanitary drain open at washing machine hook-up.

3. Opening to return air in furnace room. Closed during visit and advised occupant.

4. Furnace filter loaded and with small feathers. (No birds in house)

5. Humidifier not operating, scale but no mould

6. Basement storage room has periodic water entry (leakage) associated with rain, spring and fall. Attributable to drainage configuration at outside of house.

7. Mould on ceiling over bathtub/shower, occupant plans to install bath fan.

Mechanisms:

1. Potential mechanisms of basement floor drain, raised basement floor, open sanitary drain, and water entry/dampness in one room appear to result in higher levels of bacterium, but not mould.

2. The high levels of air change and resulting dryness appear to result in mould levels below what would otherwise be expected based on observed features.

House Number 20

Ranking:

Humidity;	23	(lowest=most humid)
Air Change;	23	(lowest=least air change)
Airborne Fungi	28	(lowest=most fungi)
I/O Fungi ratio	21	(lowest=highest ratio)
Airborne Bacterium;	23	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	27	(lowest=most microbiological activity)

Notes:

1. Humidifier not functional, dry.

2. Condensation/mould growth on master bedroom windows. Occupant reports recent replacement of same windows.

3. Master bedroom has portable vaporiser.

4. Ensuite window has active condensation and significant active mould growth.

Mechanisms:

1. Mould growth in master bedroom/ensuite is attributable to the use of portable vaporiser in this zone.

2. In all other respects there are no indicators for mould.

House Number 32

Ranking:

Humidity;	7	(lowest=most humid)
Air Change;	10	(lowest=least air change)
Airborne Fungi	2	(lowest=most fungi)
I/O Fungi ratio	4	(lowest=highest ratio)
Airborne Bacterium;	n/a	(lowest=most bacterium)
Subjective Mouldiness;	3	(lowest=most mouldy)
Overall Score;	2	(lowest=most microbiological activity)

Notes:

1. Occupant complains that they feel "draggy" in house.
2. Air Change rate of 34 l/s, 0.281 is marginally below recommended levels.
3. Recently installed natural draft gas-fired water heater may have increased air change rate in this house during measurement period, over that previously experienced.
4. Heating with airtight wood-stove, no combustion air, two floor mount small volume recirculation fans.
5. Minor seepage only water entry in basement.
6. Master-bedroom closet (on outside wall has classic black/green mould bloom.
7. Dehumidifier has scum in drain pan.(Sampled)
8. master-bedroom very mouldy head and sill.
9. living-room window has active condensation with mould growth.
10. Master-bedroom does not have active air-circulation with main area of house.

Mechanisms:

1. Master bedroom mouldiness higher than child's, attributable to higher transpiration rate of adults and lack of air circulation with balance of house.
2. High humidity attributable to high level of occupation (5 persons) and modest air-change. Note: Historical air-change may have been lower than that measured, due to a recent change in the house configuration.
3. The non-forced air heating system allows high local humidity levels in some rooms when doors are closed.

House Number 35

Ranking:

Humidity;	6	(lowest=most humid)
Air Change;	6	(lowest=least air change)
Airborne Fungi	17	(lowest=most fungi)
I/O Fungi ratio	28	(lowest=highest ratio)
Airborne Bacterium;	5	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	20	(lowest=most microbiological activity)

Notes:

1. Refrigerator condensate tray is above compressor, dry. Model WCIKNC817RT

2. Occupant primes basement floor drain traps regularly by hand.

3. Had major flood in 1978, no problem since (crack in foundation repaired).

4. Furnace humidifier functional, scale but no mould.

5. Furnace had opening in return air. Sealed at time of visit and advised occupant.

6. Air change rate of 27 l/s, 0.255 is marginally below recommended minimums.

7. Slight mould growth on children's and rear basement windows only.

Mechanisms:

1. Air change rate is marginally low, and apparently, humidity high as a consequence. This does not appear to result in higher levels of mould.

House Number 43

Ranking:

Humidity;	27	(lowest=most humid)
Air Change;	27	(lowest=least air change)
Airborne Fungi	12	(lowest=most fungi)
I/O Fungi ratio	10	(lowest=highest ratio)
Airborne Bacterium;	20	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	18	(lowest=most microbiological activity)

Notes:

1. Furnace temperature rise higher than recommended (approx 200°F bonnet temperature) advised occupant.

2. Walk-up attic has moisture staining and previously active mould growth from previous leakage around dormers and chimney, some condensation pattern staining, no active growth.

3. Cold-room under sun porch, cavity under front bay windows similar to crawlspace.

4. Pre-filter for electronic air-cleaner loaded.

5. Portable cabinet/drum type humidifier on upper level, functional.

6. Hot tub in basement, bromine water treatment, covered when not in use.

7. dryer previously vented into cavity under front bay window, now properly vented.

8. Sun-porch on second floor has roof leak.

9. Many closets on outside walls but no mould/mildew.

Mechanisms:

1. This is a dry house with lots of air change, mould levels are slightly higher than would otherwise be expected.

2. Possible sources of mould include:

   a. un-finished basement areas such as the cavities under the front bay windows and the cold-room under the sun-porch.

   b. Humidifier which has a somewhat high bacterial and fungal counts.

   c. Damp sun-porch on second floor.

House Number 56

Ranking:

Humidity;	15	(lowest=most humid)
Air Change;	15	(lowest=least air change)
Airborne Fungi	21	(lowest=most fungi)
I/O Fungi ratio	6	(lowest=highest ratio)
Airborne Bacterium;	9	(lowest=most bacterium)
Subjective Mouldiness;	10	(lowest=most mouldy)
Overall Score;	17	(lowest=most microbiological activity)

Notes:

1. Heating is electric radiant.

2. Had major flood in 1989/90 winter, have since installed full perimeter drainage and have no flooding since.

3. No floor drains in basement. previous drain covered with flooring.

4. Only active mould site identified was refrigerator drain pan.

5. Master bedroom window had a very high bacterial count and moderately high fungal count.

6. The basement fungal density was higher (181 vs 34 and 22) than the upper floors.

Mechanisms:

1. Most indicators are in the moderate range except for the indoor/outdoor fungal ratio.

2. Probable source of mould is hidden mould growth on damp materials from previous flooding. The type of basement (concrete block) is more likely to allow this mechanism.

House Number 76

Ranking:

Humidity;	10	(lowest=most humid)
Air Change;	18	(lowest=least air change)
Airborne Fungi	11	(lowest=most fungi)
I/O Fungi ratio	26	(lowest=highest ratio)
Airborne Bacterium;	2	(lowest=most bacterium)
Subjective Mouldiness;	8	(lowest=most mouldy)
Overall Score;	10	(lowest=most microbiological activity)

Notes:

1. Poor foundation, rubble, parged only to grade.
2. No basement floor drain, open sump pit, no cover.
3. Had some flooding 5-6 months ago during power failure.
4. Small basement area under kitchen area only. Soil floor crawlspace under main part of house.
5. Wood stored in basement (1-2 face cords).
6. Wood-fired central forced air heat.
7. Portable cabinet/drum type humidifier.
8. Closet at upper rear on outside wall has mildew smell, but no growth found.
9. Window in upper hall, single glazed has active condensation and mould.
10. Upper level has unvented kerosene heater, occupant reports infrequent use.
11. dryer not often used in winter, clothes hung in basement.
12. Dirty water in dehumidifier pan, growth not obvious
13. Dirty water in refrigerator pan, growth not obvious.
14. High airborne bacterium count in kitchen.

Mechanisms:

1. The reason for the high bacterial count in the kitchen is not obvious, but may be attributable to the humidifier or refrigerator condensate tray.
2. The basement fungal count is lower than would otherwise be expected due to the soil crawlspace.

House Number 84

Ranking:

Humidity;	2	(lowest=most humid)
Air Change;	2	(lowest=least air change)
Airborne Fungi	16	(lowest=most fungi)
I/O Fungi ratio	24	(lowest=highest ratio)
Airborne Bacterium;	1	(lowest=most bacterium)
Subjective Mouldiness;	5	(lowest=most mouldy)
Overall Score;	6	(lowest=most microbiological activity)

Notes:

1. Ventilation rate of 19 l/s, 0.161 ACH is lower than recommended minimums.
2. Attic has mould growth around leak from bath fan duct.
3. Two budgies in cage.
4. Baseboard electric heating.
5. Mould growth in rear bedrooms at ceiling line (slight).
6. Mould growth at bedroom window sills.
7. Front closet (outside wall) has active mould growth
8. Living room windows show sign of condensation during cold weather but no mould growth.
9. Occupant recognizes that moisture in his home is higher than desirable, runs bath-fan frequently as a consequence.
10. Clothes mostly dried in dryer, but some hung to dry.
11. Has portable vaporiser.
12. Has unvented kerosene heater, does not admit to frequent use.
13. Airborne bacterium levels high in all locations.
14. Basement floor drain sample has high bacterial count.

Mechanisms:

1. Recorded airborne mould levels are substantially lower than would be expected from air change, humidity, and observations.
2. Generally high bacterial levels are unexplained as to source, however air-change rates are substantially below recommended levels.

House Number 86

Ranking:

Humidity;	16	(lowest=most humid)
Air Change;	13	(lowest=least air change)
Airborne Fungi	19	(lowest=most fungi)
I/O Fungi ratio	8	(lowest=highest ratio)
Airborne Bacterium;	n/a	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	12	(lowest=most microbiological activity)

Notes:

1. Flooding twice 9 and 7 years ago.

2. No below grade water entry for past 7 years.

3. Furnace mounted humidifier not functional.

4. Cool mist humidifier reports daily use, does not filter water, does not report white dust.

5. Closet under stairs smells mouldy but no visible growth.

6. Closet over stairs had mould but growth but occupant reports turning down humidifier, washing closet with bleach, re-painting. Mould did not recur.

7. Condensation on Master bedroom glass, lower edges, due to closed blinds. No significant mould growth.

8. Basement airborne fungi level higher than living room and kitchen.

Mechanisms:

1. Some growth due to closed blinds in master bedroom, perhaps increased by use of portable humidifier.

2. Possible hidden mould in basement construction materials (closet).

House Number 95

Ranking:

Humidity;	24	(lowest=most humid)
Air Change;	20	(lowest=least air change)
Airborne Fungi	1	(lowest=most fungi)
I/O Fungi ratio	1	(lowest=highest ratio)
Airborne Bacterium;	6	(lowest=most bacterium)
Subjective Mouldiness;	7	(lowest=most mouldy)
Overall Score;	3	(lowest=most microbiological activity)

Notes:

1. Dryer not connected to outside.

2. Water heater shows signs of periodic back-spillage. Vent pipe does not have correct terminal, does not rise above roof-line.
   Advised occupant of problem at first visit and third visit and on telephone June 2nd 1991. Not repaired as of June 2nd 1991.

3. Extensive mould on siding adjacent to water heater vent pipe due to condensation of products of combustion.

4. Has natural gas stove/range used daily and no kitchen exhaust ventilation.

5. Main body of house is over crawlspace with soil floor.

6. Crawlspace has signs of wood fungus, but not damp at time of visit.

7. Small basement area under rear part of house, contains printing press and has gas space heater (not operating) with sub-standard vent pipe and is open to crawlspace.

8. Extraordinarily high fungal count recorded in this area (basement) with fan-door operating.

9. Cold-room adjacent to basement has open sump and substantial efflorescence from water evaporation from concrete block. Poor foundation without water-proofing in this area.

10. Closet in bathroom on outside wall has mouldy smell but no visible growth.

11. No significant fungal growth observed in upper part of house.

12. Bath fan vents into carport, significant fungal growth on siding in carport.

Mechanisms:

1. High mould levels are directly attributable to basement area.

2. Other possible sources include mould growth on siding in several areas.

House Number 96

Ranking:

Humidity;	8	(lowest=most humid)
Air Change;	11	(lowest=least air change)
Airborne Fungi	15	(lowest=most fungi)
I/O Fungi ratio	22	(lowest=highest ratio)
Airborne Bacterium;	12	(lowest=most bacterium)
Subjective Mouldiness;	7	(lowest=most mouldy)
Overall Score;	11	(lowest=most microbiological activity)

Notes:

1. Suspect that occupant intentionally opened windows prior to and during visits to obtain "good air quality".

2. Attic has mould growth on rafters at leaks around roof vents

3. Basement drainage is by sump hole with plywood cover.

4. Basement had recent major flood with most wall finishes (drywall, wood etc wetted and with mould growth.

5. Active water leakage in several locations in basement with wet construction materials and active mould growth.

6. No signs of mould observed in upper living areas of house.

7. Slight mould on basement windows, not active.

8. House foundation located below adjacent water table. Foundation type (concrete block) is not resistant to water entry.

Mechanisms:

1. Measured mould levels are substantially lower than expected considering the amount of active growth observed, and the high levels of moisture present in the basement. Measurements may however have been influenced by occupant activities.

House Number 98

Ranking:

Humidity;	9	(lowest=most humid)
Air Change;	16	(lowest=least air change)
Airborne Fungi	10	(lowest=most fungi)
I/O Fungi ratio	20	(lowest=highest ratio)
Airborne Bacterium;	10	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	14	(lowest=most microbiological activity)

Notes:

1. Attic has staining/mould marks around nails, typical of condensation from interior airborne moisture leak from house to attic.

2. Basement floor drain blocked with paper but has water in trap.

3. Lower rec room has signs of previous wetness and mould at ends of floor joists and in corners, not active at time of visit.

4. Occupant reports mould problem in lower rec room outside corner. Not active now.

5. Drum-type furnace humidifier functional with scale and mould.

6. Lower bathroom window has condensation/mould growth, attributable to higher local humidity.

7. Living room windows have condensation/mould growth attributable to sealed double glazing unit with very narrow air gap.

Mechanisms:

1. Measured mould levels are lower than expected based on the observed mould activity.

2. Sources of mould include:

   a. Humidifier,
   b. Construction materials in basement,
   c. Windows in the living room.

House Number 99

Ranking:

Humidity;	5	(lowest=most humid)
Air Change;	9	(lowest=least air change)
Airborne Fungi	26	(lowest=most fungi)
I/O Fungi ratio	17	(lowest=highest ratio)
Airborne Bacterium;	21	(lowest=most bacterium)
Subjective Mouldiness;	10	(lowest=most mouldy)
Overall Score;	26	(lowest=most microbiological activity)

Notes:

1. Attic has sign of previous wood fungus, not active now.

2. 2 Budgies in cage.

3. Recently installed sealed combustion gas forced air heating system in attic. (House was previously electric baseboard).

4. Heating system is equipped with fresh air intake.

5. Occupant reports that previous high humidity/mould problem now cured by installation of new heating system.

6. House shows signs of previous mould activity on most windows, and at ceiling etc. No active mould could be found on exterior surfaces.

7. Although Air Changes per hour is 0.328, recorded air change volume is only 32 l/s (volume relationship is not typical because of slab-on-grade configuration). According to CSA F326, the required minimum ventilation capacity for this home would be 45 l/s.

Mechanisms:

1. This house has had previous high mould levels which have been corrected by changing the ventilation rate in the house.

2. Measured air-change rate continue to be somewhat low. Previous air change rates would have been even lower.

House Number 101

Ranking:

Humidity;	3	(lowest=most humid)
Air Change;	1	(lowest=least air change)
Airborne Fungi	6	(lowest=most fungi)
I/O Fungi ratio	10	(lowest=highest ratio)
Airborne Bacterium;	10	(lowest=most bacterium)
Subjective Mouldiness;	1	(lowest=most mouldy)
Overall Score;	1	(lowest=most microbiological activity)

Notes:

1. Attic has good ventilation and only slight sign of moisture, leak at chimney, lots of mice.

2. Batt insulation (6") in attic parted around roof truss ends @ outside walls, corresponds to mould marks on interior ceiling.

3. Furnace humidifier not functional but pan has water with scum.

4. Occupant sets temperature back during day and at night about 10°C.

5. During visits, living area temperature only 17-18°C

6. House has extensive mould growth on exterior surfaces;

   a. Upper level ceiling, spots corresponding to roof truss locations, at attic hatch.

   b. All upper level window bottom edges/sills.

   c. Patio door (covered with obstructing, heavy drapery) covered with active condensation and mould.

   d. lower wall location in kitchen area, probably missed insulation during construction.

   e. Basement single-glazed windows (extensive).

   f. Exterior, upper corners of uninsulated concrete block basement. (Rises above grade about 36-48")

7. Occupant reports water dripping from kitchen bulkhead during cold wether, but not recently.

8. Refrigerator drain pan full and covered with variety of thriving mould colonies. Pan is not heated.

9. No external water entry in basement.

10. Basement drain trap has water (served by washing machine).

11. House has seven occupants.

House Number 101 cont'd

Mechanisms:

1. Higher levels of occupation, combined with extremely low air change contribute to high humidity levels.

2. Low levels of air-change result from large set-back changes which substantially reduce heating-plant operation (which consumes air) and stack-effect.

3. Large set-back differentials result in a condition where many building surfaces are at or below the interior air dewpoint on a regular basis. (Dewpoint temperature of 11°C recorded on one visit, set back is to about 10°C).

4. Single glazed basement windows are below dewpoint during most winter weather.

5. Raised bungalow design, in exposed location with uninsulated basement and brick veneer, results in interior basement wall surface temperatures in upper corners which are frequently below the dewpoint.

6. Heavy drapes in front of patio door contribute to higher levels of condensation and mould growth in that location.

7. Low levels of attic insulation, and poor detail around truss penetration result in colder spots at truss locations.

8. Because of low average dewpoint temperature, evaporation rate from refrigerator defrost drain pan is such that it is constantly wet, resulting in high levels of mould growth at this location. The pan is not located so that a source of heat (compressor or condenser) would cause evaporation in these circumstances.

House Number 106

Ranking:

Humidity;	18	(lowest=most humid)
Air Change;	24	(lowest=least air change)
Airborne Fungi	24	(lowest=most fungi)
I/O Fungi ratio	27	(lowest=highest ratio)
Airborne Bacterium;	24	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	28	(lowest=most microbiological activity)

Notes:

1. Attic in excellent condition with no moisture sign, good ventilation.

2. Basement floor drain has clear water in trap.

3. Occupant reports water entry through crack in foundation repaired 1983, no problem since.

4. Occupant reports minor water entry around air-conditioning feed in furnace room every spring; no dampness, mould observed at time of visit.

5. Storage room in basement smells mouldy but no growth found.

6. Bath inside shower and window sill show some mould growth.

7. Gas range/oven with functioning range hood exhaust fan.

8. This house has a large (24") "inter-floor" space which does not have an interior finish and leads to more air-leakage than would be expected for a house of this size.

Mechanisms:

1. Although a potential source of mould was identified, this house has very low levels of microbiological air contaminants.

House Number 108

Ranking:

Humidity;	11	(lowest=most humid)
Air Change;	8	(lowest=least air change)
Airborne Fungi	13	(lowest=most fungi)
I/O Fungi ratio	25	(lowest=highest ratio)
Airborne Bacterium;	17	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	22	(lowest=most microbiological activity)

Notes:

1. Kitchen fan is vented into attic.

2. Basement floor drain covered with flooring, only small holes, unable to inspect.

3. Furnace mounted humidifier not used, scale but no mould.

4. Dehumidifier in use in basement all year round.

5. Furnace filter loaded.

6. Sealed combustion gas furnace installed 6 years ago.

7. Occupant reports moisture problem 6 years ago corresponding to furnace change. Had fog on windows, black stuff on window sills etc., but this was controlled when "something" done to "increase ventilation".

8. Flue from original furnace is open and active. Suspect that "something" refers to re-opening of flue if blocked at installation of new furnace.

9. Some previous flooding in basement related to defective down-spout.

10. Garage (attached) smells mouldy. Suspect poor ventilation water entry in attic over garage but unable to inspect.

Mechanisms:

1. The only potential source of mould identified was the garage, but this does not appear to affect the indoor environment.

House Number 110

Ranking:

Humidity;	19	(lowest=most humid)
Air Change;	12	(lowest=least air change)
Airborne Fungi	22	(lowest=most fungi)
I/O Fungi ratio	11	(lowest=highest ratio)
Airborne Bacterium;	22	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	23	(lowest=most microbiological activity)

Notes:

1. Basement drain is via open sump with plywood cover.

2. Some active leakage in basement around water entry, some mould growth.

3. Occupant reports previous mildew closet outside wall but cleaned and has not recurred.

4. Occupant acquired house in April of 1985; basement usually had 6" water depth.

5. Recent upgrades to basement include complete exterior excavation with new perimeter drain, water proofing, interior drainage and sump. Only remaining work is around water entry point.

6. Basement sump full, (plywood cover) serves washing machine, (soapy water), wood framing rotting.

Mechanisms:

1. Although there are potential sources of mould, this is not reflected in the quantitative measurements.

2. This house may have had higher historical levels of dampness and mould growth.

House Number 114

Ranking:

Humidity;	17	(lowest=most humid)
Air Change;	22	(lowest=least air change)
Airborne Fungi	3	(lowest=most fungi)
I/O Fungi ratio	2	(lowest=highest ratio)
Airborne Bacterium;	3	(lowest=most bacterium)
Subjective Mouldiness;	7	(lowest=most mouldy)
Overall Score;	4	(lowest=most microbiological activity)

Notes:

1. Attic not wet at time of visit but moisture stains. Staining at upper part corresponds to leakage.
2. Wooden/brick/soil floor in basement no drains.
3. Rubble/fieldstone foundation poor condition.
4. Occupant reports some basement water entry every spring and during heavy rains.
5. Active wetness and seepage form foundation wall at time of visit.
6. Active mould growth in basement where new wood framing in contact with floor, and on existing brick floor.
7. Electric forced air heating.
8. Furnace humidifier dry, not functional.
9. Closet on outside wall, under front stairs has mouldy smell and visible growth.
10. Laundry has mouldy smell, but this is probably from basement.
11. Basement has strong mouldy smell.
12. All windows in upper level have condensation and some mould growth between panes, never on house side of glass.
13. High levels of airborne fungi and bacterium recorded in all areas especially basement.

Mechanisms:

1. The basement appears to be the source of higher levels of airborne mould and bacterium
2. The species of bacterium (Bacillus cereus) most numerous in the air samples was isolated from the basement soil sample, which points to the basement as the source.

House Number 119

Ranking:

Humidity;	21	(lowest=most humid)
Air Change;	19	(lowest=least air change)
Airborne Fungi	18	(lowest=most fungi)
I/O Fungi ratio	7	(lowest=highest ratio)
Airborne Bacterium;	15	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	13	(lowest=most microbiological activity)

Notes:

1. Attic has good ventilation and no moisture sign.

2. Basement floor drain smells bad.

3. Airtight wood stove used daily winter. House had smell of wood-smoke on both visits. Occupant reports occasional back-puffing during windy weather. Masonry chimney terminal is lower than main roof of house.

4. Furnace mount humidifier functional with scale and no mould.

5. Portable cool-mist humidifier in living room.

6. Occupant reports mould at base of walls and smell in basement during summer. Recently painted over.

7. Upper windows have mould between glazings. Only one window in ensuite bath with condensation and mould.

Mechanisms:

1. Possible sources of mould include the basement wall finish (hidden mould) indicated by basement airborne mould levels which are substantially higher than that for the upper level.

2. The higher level of products of combustion (wood smoke) is an air-quality concern in this house.

House Number 126

Ranking:

Humidity;	22	(lowest=most humid)
Air Change;	17	(lowest=least air change)
Airborne Fungi	11	(lowest=most fungi)
I/O Fungi ratio	13	(lowest=highest ratio)
Airborne Bacterium;	n/a	(lowest=most bacterium)
Subjective Mouldiness;	9	(lowest=most mouldy)
Overall Score;	8	(lowest=most microbiological activity)

Notes:

1. New home

2. Attic not accessible

3. Basement sump has clean water.

4. Freezer in basement has mould on gasket, On inquiry, this freezer, recently moved from house #101.

5. Has HRV, runs continuously according to occupant (not confirmed by air-change measurement) measured flow-rate of 62 l/s fresh, 72 l/s exhaust.

6. Marginal ACH rate of 0.228, but volume flow is 59 l/s. (The house has a large volume.)

7. Forced air heat-pump heating system, no active flues in house.

8. Dirt and some mould in HRV fresh air drain pan.

9. Mould growth not observed in living area of house.

Mechanisms:

1. Mould growth in the fresh-air side of the HRV could be distributed into the house.

2. Non-combustion heating system does not induce air-change other than via the HRV.

House Number 127

Ranking:

Humidity;	28	(lowest=most humid)
Air Change;	28	(lowest=least air change)
Airborne Fungi	27	(lowest=most fungi)
I/O Fungi ratio	18	(lowest=highest ratio)
Airborne Bacterium;	16	(lowest=most bacterium)
Subjective Mouldiness;	10	(lowest=most mouldy)
Overall Score;	25	(lowest=most microbiological activity)

Notes:

1. Attic has previous leakage around chimney.
2. Forced warm air heating ducts in attic.
3. Had flooding in basement 7 years ago, controlled now after installation of new drainage.
4. Sill area has very high rate of air leakage.
5. Humidifier drum type, functional with scale, no mould.
6. No mould, mildew observed in this house.
7. Carpeted area in basement, suspect mould but in summer, not winter.
8. There are no indications of active mould growth in this house at the time of visit.

Mechanisms:

1. The carpeted basement area is a possible source of mould, but appears only to have sufficient moisture in summer.

House Number 129

Ranking:

Humidity;	13	(lowest=most humid)
Air Change;	7	(lowest=least air change)
Airborne Fungi	14	(lowest=most fungi)
I/O Fungi ratio	23	(lowest=highest ratio)
Airborne Bacterium;	18	(lowest=most bacterium)
Subjective Mouldiness;	8	(lowest=most mouldy)
Overall Score;	19	(lowest=most microbiological activity)

Notes:

1. Carport has extensive mould growth on underside of structure, outside fungal air sample taken adjacent. This may have influenced the indoor/outdoor fungal density ratio.

2. Attic has medium wood fungus growth, not active winter.

3. Attic has 2-3" wood chip insulation, 4" batt insulation piled on one side of attic, not spread out. Suspect "Bandit" type insulation contractor.

4. Attic ventilation pots installed but sheathing not properly cut-out where installed reducing ventilation effectiveness. See previous note.

5. Basement has open sump.

6. No signs of current leakage in basement but house is located in low area. Occupant reports that neighbours without sump have flooding. Judged basement to be surprisingly dry considering age, construction and location/grading of house.

7. Dryer has switch-over box, directed inside.

8. Pet Cockatiel, caged.

9. Furnace humidifier not functional.

10. Occupant reported basement mouldy smell until dehumidifier purchased one year ago.

11. Mouldy smell in basement finished area and in cold room.

12. Active mould growth between inner and outer window panes.

13. Active mould growth on kitchen exterior door panel, (covered on exterior by aluminum storm/screen door).

Mechanisms:

1. This house may have an erroneous ranking because of the location of the outdoor sample.

2. Sources of Mould are most likely to be from the basement area.

House Number 131

Ranking:

Humidity;	20	(lowest=most humid)
Air Change;	14	(lowest=least air change)
Airborne Fungi	5	(lowest=most fungi)
I/O Fungi ratio	3	(lowest=highest ratio)
Airborne Bacterium;	13	(lowest=most bacterium)
Subjective Mouldiness;	8	(lowest=most mouldy)
Overall Score;	5	(lowest=most microbiological activity)

Notes:

1. Bath fan vents to attic but only moisture sign related to leak at chimney.

2. Floor drain basement under carpet not accessible.

3. Has attached crawlspace but clean and dry with cast in place concrete floor.

4. Gas range/stove, no kitchen fan.

5. Gas direct vent fireplace used daily.

6. Refrigerator drain pan recently cleaned by occupant.

7. Basement bedroom:

   a. Had dehumidifier running at time of visit.

   b. Mould growth (dry) on walls, wallpaper lifted.

   c. Signs of active water evaporation from surface, outside shows probable water entry routes/poor drainage in this location.

   d. Inside wall surface temperature measured 13.5°C, with outside temp of -4°C.

8. Bedroom windows with wood frame, aluminum cladding, have condensation and mould on lower edge. Occupant reports frost during cold wether. Measured surface temp of 11°C with -4°C outside temperature. This type of window is known to be problematic with respect to condensation because of the action of the aluminum cladding in lowering the glass edge temperature.

9. Portable drum type humidifier functioning.

10. Occupant complained of "funny Smell" from furnace. Identified as "burnt dust" smell occurring when furnace not fired for long periods of time (10-24 hours) due to operation of fireplace and temperature set-back.

House Number 131, cont'd

Mechanisms:

1. This house has a mouldy basement area, at an exterior wall where the source of water is external leakage. This may be supplemented in the summer by condensation on the massive, uninsulated foundation wall.

2. Several of the windows in the house are of a type which, because of their design, have a tendency to condense water around their perimeters at normal household conditions, ie; condensation would not be expected on a "normal" double-glazed window. This leads to eventual mould growth.

3. Although there is a crawlspace attached, there is no exposed soil, so that this has been discounted as a mechanism.

House Number 139

Ranking:

Humidity;	1	(lowest=most humid)
Air Change;	5	(lowest=least air change)
Airborne Fungi	8	(lowest=most fungi)
I/O Fungi ratio	13	(lowest=highest ratio)
Airborne Bacterium;	8	(lowest=most bacterium)
Subjective Mouldiness;	7	(lowest=most mouldy)
Overall Score;	7	(lowest=most microbiological activity)

Notes:

1. Attic has good ventilation and is dry.

2. Washing machine leaks onto basement floor with active mould growth and stain.

3. Electric baseboard heating.

4. Mould locations as follows:

   a. master-bedroom ceiling exterior corner and wall edge.

   b. Master-bedroom closet ceiling (outside wall)

   c. Pella windows between glazings

   d. Living-room windows at glazing spacers (7.5°C)

   e. Sliding windows on inside glass (10°C.

   f. Girls bedroom closet on outside wall.

5. Condensation on Pella windows, between panes, sliding windows and at front windows at glazing spacer.

6. Dehumidifier runs constantly upper level winter, basement in summer.

7. Air change rate of 0.189 ACH and 22 l/s volume flow-rate are somewhat lower than recommended levels.

Mechanisms:

1. Low air change rate leads to higher levels of humidity which lead to local condensation and consequent mould growth.

2. Electric heating does not consume air (as would be the case for a combustion-based heating system and so does not induce additional ventilation.

3. Non-forced air heating may allow higher local levels of humidity (in bedrooms for example) than would be the case for a forced-air heating system.

	VISITS		OUTDOOR CONDITIONS				Temperature			INSIDE CONDITIONS								INSIDE CONDITIONS cont'd					
										Visit 1								Visit 2					
										Upper Level				Basement				Upper Level				Base	Base
Hse No.	V1 Date	V2 Date	V1 DB T	V1 HR	V2 DB T	V2 HR	No. Occ	Stat Temp	Stat Set	Stat Switch	up DB T	up RH%	up HR	up I/O HR dif	Base DB T	Base RH%	Base HR	Base I/O HR dif	up DB T	up RH%	up HR	up I/O HR dif	Base DB T	Base RH%
1	Mar-25	Mar-26	5.0	0.0040	10.5	0.0010	4	21.0	20.0	20.0	20.5	53%	0.0079	0.0039	20.0	52%	0.0075	0.0035	19.5	47%	0.0067	0.0057	19.5	47%
3	Jan-14	Jan-15	2.0	0.0027	5.0	0.0043	3	n/a	18.3	n/a	20.0	36%	0.0055	0.0028	not available				20.5	46%	0.0070	0.0027	not av	
6	Mar-25	Mar-26	3.5	0.0037	10.5	0.0046	6	21.0	20.5	20.5	21.0	39%	0.0061	0.0024	17.0	47%	0.0057	0.0020	21.0	39%	0.0061	0.0013	18.0	48%
12	Jan-21	Jan-29	-12.5	0.0013	-1.0	0.0036	4	21.0	21.0	20.5	18.5	26%	0.0037	0.0024	17.5	29%	0.0037	0.0024	20.5	36%	0.0058	0.0022	17.5	36%
14	Jan-21	Jan-22	-11.5	0.0014	-7.0	0.0021	6	20.5	19.4	?	22.0	34%	0.0055	0.0041	24.0	26%	0.0047	0.0033	20.5	31%	0.0047	0.0026	20.0	30%
20	Jan-21	Jan-22	-14.0	0.0011	-7.5	0.0020	4	21.5	21.7	19.4	20.0	37%	0.0055	0.0044	18.0	34%	0.0044	0.0033	20.5	32%	0.0050	0.0030	21.5	30%
32	Feb-4	Feb-5	7.7	0.0045	3.0	0.0043	5	n/a	n/a	n/a	20.2	50%	0.0072	0.0027	19.2	43%	0.0060	0.0015	20.5	46%	0.0071	0.0028	19.2	46%
35	Mar-18	Mar-19	8.0	0.0056	8.5	0.0048	4	22.5	20.0	23.0	22.5	36%	0.0065	0.0007	20.0	44%	0.0065	0.0007	21.5	50%	0.0060	0.0032	17.0	56%
43	Feb-11	Feb-12	-8.0	0.0019	-3.0	0.0029	4	22.0	20.5	19.5	21.0	26%	0.0041	0.0022	21.6	26%	0.0043	0.0024	22.5	25%	0.0042	0.0013	23.0	27%
56	Jan-14	Jan-15	2.0	0.0020	1.5	0.0036	4	21.5	18.3	n/a	21.4	42%	0.0068	0.0048	not available				21.5	36%	0.0059	0.0021	22.5	32%
78	Feb-18	Feb-19	1.5	0.0042	4.0	0.0050	5	23.5	26.0	25.6	23.5	32%	0.0059	0.0017	23.0	39%	0.0068	0.0026	19.0	50%	0.0069	0.0019	20.5	45%
84	Mar-18	Apr-9	2.5	0.0048	n/a	n/a	4	21.5	20.6	20.6	21.5	50%	0.0080	0.0032	20.0	48%	0.0070	0.0022	no second visit				no sec	
86	Feb-1	Feb-12	-5.0	0.0025	-2.5	0.0031	4	21.5	21.5	22.0	22.0	34%	0.0056	0.0031	20.1	42%	0.0063	0.0038	20.0	37%	0.0055	0.0024	19.0	43%
92	Jan-28	Jan-29	0.0	0.0038	-1.0	0.0036	5	24.0	17.0	18.0	23.0	33%	0.0058	0.002	8.5	69%	0.0042	0.0004	22.5	32%	0.0055	0.0019	8.5	67%
96	Mar-18	Mar-18	5.0	0.0055	4.5	0.0041	6	21.0	19.2	19.4	20.5	49%	0.0073	0.0018	17.0	55%	0.0067	0.0012	20.5	45%	0.0067	0.0026	18.0	54%
98	Feb-25	Feb-26	0.5	0.0039	-0.2	0.0037	6	19.7	16.7	17.2	18.6	49%	0.0067	0.0026	19.0	45%	0.0062	0.0023	20.0	51%	0.0075	0.0038	18.5	46%
99	Feb-11	Feb-12	-7.5	0.0020	-3.0	0.0029	4	22.3	22.0	22.0	21.5	31%	0.0071	0.0051	not available				22.0	31%	0.0072	0.0043	not av	
101	Feb-25	Feb-26	-4.0	0.0027	-8.0	0.0019	7	18.0	12.0	12.0	18.0	65%	0.0084	0.0057	14.0	70%	0.0069	0.0042	17.0	59%	0.0072	0.0053	14.7	66%
106	Mar-26		9.0	0.0043	n/a	n/a	5	19.0	19.0	19.0	21.0	36%	0.0056	0.0013	19.5	40%	0.0057	0.0014	no second visit				no sec	
108	Mar-25		8.0	0.0050	n/a	n/a	4	20.7	23.3	n/a	20.0	20%	0.0065	0.0015	22.5	39%	0.0065	0.0015	no second visit				no sec	
110	Jan-28	Jan-29	-2.0	0.0032	0.0	0.0036	5	21.7	19.4	20.0	21.5	36%	0.0059	0.0027	19.5	35%	0.0050	0.0018	21.5	34%	0.0055	0.0017	19.5	36%
114	Mar-11	Mar-12	-8.5	0.0021	0.0	0.0036	4	21.7	21.1	?	21.0	39%	0.0060	0.0039	11.0	66%	0.0055	0.0034	19.5	40%	0.0057	0.0019	11.0	66%
119	Jan-28	JAn-29	0.0	0.0038	0.0	0.0036	4	18.5	off	18.3	21.0	28%	0.0045	0.0007	22.0	34%	0.0055	0.0017	18.5	40%	0.0054	0.0016	18.5	40%
126	Feb-4	Feb-5	6.2	0.0041	2.7	0.0041	4	21.5	21.5	21.5	22.0	32%	0.0054	0.0013	14.5	40%	0.0042	0.0001	20.3	36%	0.0054	0.0013	15.3	44%
127	Jan-21	Jan-22	-7.0	0.0021	-7.0	0.0021	5	22.5	24.0	24.0	21.0	14%	0.0023	0.0002	not available				21.4	20%	0.0032	0.0011	19.0	23%
129	Feb-18	Feb-19	3.0	0.0042	8.5	0.0067	5	24.5	20.0	20.6	23.5	34%	0.0064	0.0022	21.7	37%	0.0060	0.0018	22.5	38%	0.0065	-0.0002	22.5	36%
131	Feb-25	Feb-26	0.0	0.0036	-4.0	0.0027	3	23.0	21.0	22.5	21.7	36%	0.0063	0.0025	18.6	43%	0.0058	0.0020	21.5	30%	0.0048	0.0021	18.5	39%
139	Mar-11	Mar-12	-5.5	0.0023	-3.0	0.0029	4	n/a	20.0	20.8	23.0	46%	0.0079	0.0056	23.0	51%	0.0091	0.0068	23.0	46%	0.0065	0.0056	22.0	44%

Hse No.	Base HR	Base I/O HR dif	Age Yrs	Adj Shrubs?	Birds? Bats?	House Type	Number Stories	Abv Grade Wall Finish	Cond?	Foundation Type	Exterior Finish	Cond?	Roof Mat'l	Cond	Other	Wall Finish 1	Wall Finish 2	Wall Finish 3	Frame	Type 1
	ment																			
1	0.0067	0.0057	40	0	0	Bung	1	Cement prg	E	CBlk	prg	F	Asph Sh	VG	A	Plaster-Pnt	Plaster-Wppr	PPlywd	Wood	Wd DH SG Alu Stm
3	allable		15	0	0	Bung	1	Brick/Plywd	G	Clp	prg	F	Asph Sh	G		DWall-Pnt			Wd 2x4	Wd Dg Vy Sldr
6	0.0063	0.0015	70	0	0	2-sto	2	Stucco	F	Clp/CBlk		F	Asph Sh	G		Plaster-Wppr			Wd 2x4	Wd Sg Alu Stm
12	0.0046	0.0010	43	8	0	2-sto	2	Vinyl	G	Clp		G	Asph Sh	G	B	PPlywd-pnt	PPlywd-Var	PPlywd	Wd 2x4	Wd Sg Alu Stm
14	0.0045	0.0024	29	0	0	Bung	1	Brick	G	CBlk		F	Asph Sh	G		DWall-Pnt	DWall-Npnt		Wd 2x4	Wd Dg Shls Sldr
20	0.0048	0.0028	17	0	0	R-Bung	1	Alu Side	G	Brick/Clp		G	Asph Sh	G		Dwall-Pnt	PPlywd		Wd 2x4	Wd Dg Sld .5"
32	0.0065	0.0022	6	0	0	Bung	1	Cedar R&B	G	Clp		G	Asph Sh	G		Dwall-Pnt	Dwall-Npnt	DWall-VWppr	Wd 2x4	Wd Dg Sld .5"
35	0.0067	0.0019	13	0	0	Ranch	1	Brick/Metal	G	Clp		G	Asph Sh	G		Dwall-Pnt			Wd 2x4	Wd Dg Sld .5"
43	0.0048	0.0019	56	0	0	2-sto	2	Brick	G	Clp		G	Metal Tile	G	C	Plaster-Pnt			WD-Bal	Alu Stm Dbl (In/Out)
56	0.0055	0.0017	29	0	0	Bung	1	Brick	G	CBlk	prg	G	Asph Sh	G		Plaster-Pnt			Wd 2x4	Wd Dg Shls Sldr
76	0.0068	0.0018	91	0	0	2-sto	2	False Brick	P	Rubble	prg	P	Asph Sh/Met	G		DWall-Pnt	Plaster-Pnt	PPlywd	Wood	Wd Sg Alu Stm
84	ond visit		15	0	0	Bung	1	Brick	G	Clp		G	asph Sh	G		DWall-pnt	DWall-Wppr		Wd 2x4	Wd Dg Inr Stm
86	0.0058	0.0028	11	0	0	Ranch	1	Brick	G	Clp		G	Asph Sh	G		DWall-Pnt			Wd 2x4	Wd Dg Sld .5"
95	0.0040	0.0004	55	0	0	1.5 sto	1.5	Vinyl ovr Asph	G	CBlk	N/prg	P	Asph Sh	F	DE	PPlywd	Various		Wood	Wd Sg Alu Stm
96	0.0061	0.0020	24	0	0	Bung	1	Brick	G	CBlk		G	Asph Sh	G	F	PPlywd	Various	Barn Bd(Wet)	Wd 2x4	Wd Sg Alu Stm
98	0.0061	0.0024	16	0	0	Split	1.5	Brick Alu S	G	Clp	prg	G	Asph Sh	G		DWall-Pnt	PPlywd		Wd 2x4	Wd Dg Sld .125"
99	allable		17	0	0	Bung	1	Plywd-Stain	G	Clp		G	Asph Sh	G		DWall-Pnt	DWall-Wppr		Wd 2X4	Wd Dg .625"
101	0.0069	0.0050	14	0	0	Bung	1	Brick	G	CBlk	prg	G	Asph Sh	G		DWall\pnt			Wd 2x4	Wd Dg Sld .5"
108	ond visit		13	0	0	Split	1.5	Brick Alu S	G	Clp	prg	G	Asph Sh	G		DWall-Pnt	DWall-Wppr	PPlywd	Wd 2x4	Wd Vcld Sld .5"
108	ond visit		40	0	0	Bung	1	Wood Side	G	CBlk	prg	G	Asph Sh	G		Plaster-Wppr			Wood	Wd Sg Wd Stm
110	0.0052	0.0014	34	0	0	Bung	1	Brick	G	CBlk	prg	Vg	Asph Sh	G	G	Plaster-Wppr		Wd Panel	Wd 2x4	Wd Sg Alu Stm
114	0.0055	0.0017	99	0	0	2-Sto	2	Brick	G	rub/stone		P	Slate Sh	G		DWall-Pnt	DWall-wppr	PPlywd	Wood	Wd Sg Alu Stm
119	0.0055	0.0017	16	0	0	2-sto	2	Brick Alu S	G	Clp		G	Asph sh	G		Dwall-Pnt	DWall-Wppr		Wd 2x4	Wd Sg Alu Stm
126	0.0047	0.0006	1	0	0	Ranch	1	Brick	G	Clp		G	Asph Sh	G		DWall-Pnt			Wd 2x4	Wd Dg .625"
127	0.0032	0.0011	100	1	0	2-Sto	2	Alu Side	G	Rubble	prg	VG	Asph Sh	G		DWall-Pnt	DWall-Wppr		Wood	Wd Sg Alu Stm
129	0.0060	-0.0007	50	1	0	Bung	1	Alu Side	G	Clp		P	Asph Sh	G	H	Dwall-Pnt	PPlywd		Wood	Wd Sg Alu Stm
131	0.0045	0.0018	39	0	0	Bung	1	Alu Side	G	CBlk		P	Asph Sh	G	I	DWall-Pnt			Wood	Wd AlucladDg Sld .5"
139	0.0073	0.0044	16	0	0	Bung	1	Brick	G	Clp		G	Asph Sh			DWall-Pnt			wd 2x4	Wd Dg Sshls Sldrs

HOUSE OUTSIDE DESCRIPTION — 0=No, 1=yes

INSIDE DESCRIPTION

WINDOWS

E=Excellent
VG=Very Good
G=Good
F=Fair
P=Poor

CBlk=Concrete Block
prg=Parged
Clp=Cast In Place

OTHER
A New addition Hair Salon, Vinyl siding, PWF fdn
B Large overhanging tree front yard, mould on siding
C New Roof on Furring over Asph Sh
D Mould on Siding by DHW vent
E Mould on Siding by Carport (Bath Fan Vent)
F Occuopant conplains of Roof Leaks
G Recent new drainage
H Carport has much Mould on underside
I Poor Grading

Wd=Wood
Sg=Single Glazed
Dg=Double Glazed
Stm=Storm
Alu=Aluminum
Vy=Vinyl
Vclad=Vinyl Clad
Aluclad=Aluminum Clad
Sshls=Sashless
Sldr=Slider
PDoor=Patio Door
Dimension eg. 0.5" refers to

			ATTIC									BASEMENT									
Hse No.	Type 2	Type 3	Cathedral Ciel ?	Ciel Fan?	Fungi?	Moist?	Insul Type	Inches Insul Depth	Birds? Bats?	Ventilation	Other	Basement Finished %	birds? Bats?	Floor drain Exist?	Floor drain Trap?	Floor drain Dry?	Other	Sanitary Drain Open?	Floor Raised?	Carp. Conc?	Other Finish
1	SG Alu Stm (Base)		0	Salon	0	0	Batt+blown	10	0	High/Low power-VG		0%	0	1			A	0	0	All	0
3			0	0	0	0	Blown	?	0	High/Low-G	No Acc	0%	0	1				0	0	0	Clp
6			0	0	1	1	Batt	6	0	Perim-G	Wlk-up	0%	0	0				0	0	0.5	Clp
12	Wd Sg (Base)		0	0	1	1	RWool	10		Gable-G	No VB	50%	0	1	Cap	Y	BCDE	Leak	0	0.33	Clp
14	PDoor Dg Sld		0	0							No Acc	100%	0	1	1	0	D	Washer	0.25	0.25	Clp
20	Wd Dg Sld .25"		0	0							No Acc	100%	0	1	0	0	F	0	0	1	0
32			0	Family	0	0	Batt	12	0	Turbine-G		100%	0	1	1	0		0	0	0.5	Clp-Pnt
35			0	Kitchen				12		High-Low	No Acc	100%	0	1	1	0	G	0	0	1	0
43		Wd Sg Alu Stm	0	0	1	0	RWool	6	0	High-Leakage	Wlk-up	50%	0	0				0	0	0.5	Clp
56	Wd Dg Sld .5"		0	Bdr's	0	0	RWool/Batt	10	0	Perim/Forced-G		50%	0	0				0	0	0.5	Clp
76	Wd Sg		0	0							No Acc	0%	0	1		0	H	0	0	0	Clp
84	Vy Dg Sldr	Wd Sg Alu Stm	0	0	3	3	Blwn FG	8	0	High/low-G		100%	2 budgi	1	1	?		0	0	0.5	Clp
88	Wd Sg Inr Stm		0	0	0	0	?	?	0	Soffit	Part Acc	100%	0	1	1	0		0	0	0.5	Clp
95			0	0							No Acc	0%	0	1	1	0	I	?	0	0	Clp/0
96	Vy Dg Sld .5"		0	Living	2	2	Blown FG	12	0	High/Low-F	ABC	50%	0	0			J	0	0	0	Clp-Pnt
98	Wd Dg Sld .125" Alu Stm		0	Family	2	2	Batt	6	0	Poor/Small	Poor Acc	75%	0	1	1	0	K	0	0	0.75	Clp
99			0	0	5	0	Batt	12	0	Perimeter	J	0%	2 budgi		no basement			0	0	1	0
101	Wd Sg (Base)		0	0	0	4	Batt	6	Mice	High/Low-G	DE	0%	0		0	0		0	0	0	Clp
108	Wd Dg Sld .5"		0	0	0	0	Cellu	6	0	Soffit/Pwr-E	VDry	90%	0	1	1	0	L	0	0	0.9	Clp-Pnt
108	Wd Dg Sld .5"	Vy Dg Sld .5"	0	0	0	4	Batt	6	0	High-Low-G	DF	100%	0	1	1	?	A	0	0	0	Clp
110	Wd Sg Innr Stm		0	0	0	0	Blown	12	Ded Ms	High	VDry	75%	0	1	0	0	J	0	0	0.75	Clp
114			0	Kit/Liv	1	1	Blown	6	Mice	Blocked	GH	0%	Bees	0	0		M	0	0	0	Br/Soil
119	Wd Sg Alu Stm		0	0	0	0	Batt	12	0	High/Turb-G		100%	0	1	1	0	D	0	0	0.5	Clp-pnt
126	Wd Dg Vy Sldr		LR	0	0	0	Blown FG	10	0	Perim-G	Poor Acc	0%	0	1	0	0	J	0	0	0	Clp
127	Alu Stm Sg		0	0	0	1	Batt	6	0	Not Obvious	DI	75%	0	0				0	0	0.5	Clp
129			0	0	1	0	Wd Chips	2.5	0	Poor/fair	KL	40%	0	1	1	0	H	0	0	0.4	Clp
131	Wd Vclad Dg Sld .5"	Wd Sg Alu Stm	0	0	0	4	Blown MWool	6	0	High/Gable/Soffit	FD	50%	0	A				0	0	0.4	Clp-Pnt
139	Wd Dg Sld .5"	Wd Sg	0	0	0	0	Blown	6	0	High/Low-G		30%	0	1	1	0	N	0	0	0.3	Clp-Pnt

ATTIC
0=No sign
1=Marks but dry/not active
2=Active/wet
3=Marks associated with fan venting into attic
4=Marks associated with leakge
5=Wd fungus marks, dry, not active

glazing space

OTHER-ATTIC
A=Mould Moisture on rafters (slight)
B=Leaks around roof vents
C=leaks over entrance
D=leak at chimney
E=Insul parts @ roof joists/truss corresponds to mould marks on ceiling below
F=Fan vented into attic
G=Poor Ventialtion
H=Possible leakage at flat roof
I=Heating Ducts in attic
J=Furnace in attic
K=High vents not cut otu fully
L=Batt insul not spread out

DRAIN
A covered with carpet/flooring
B no primer
C Wet
D Bad Smell
E Plugs Often
F Primed
G H'owner puts water in
H Open Sump Pit
I Sump in Cold Room
J Covered Sump
K Blocked with Paper
L Clear Water
M Soil Floor, no drains
N Washer leaks Mould on Floor

OTHER-BASEMENT
A Leaks most spring through CBlk
B Mouldy/Scat smell in Furnace Room under P
C Cold Room attached
D New Perimeter Drainage, ___ yr
E Wood Stored in Base (1-2 cords)
F Family uses Shower in Base
G Printing Press in base
H No cover of crawlspace soil
I Many wet construction mat'ls
J active leakage
K major previuos flood-not dry yet
L Marks of prev wetness @ flr joist ends/dry n
M Slab on Grade House
N Previous Fungus/moisture gone since furnac
Z Extensive Mould, windows, Wall Corners ab
P Small leak, each spring @ AC entry
Q Small occasional Leak-when downspout lea
R Occasional Mould/Mildew @ base of Wall p
S Mouldy Freezer from House #101
T HRV flows 125-145 cfm continuous
U mouldy walls below grd in beroom

					MECHANICAL-Misc						MECHANICAL-Ventilation					MECHANICAL														
																-----HEATING----				-----HOT WATER---			HUMIDIFIER---			---DEHUMIDIFIER----			SET BACK	
Hse No.	Crawl Space?	Prev. Flood?	Current Leak?	Other	AIR COND. Wind?	Cent?	FIREPLACE Type	Use	WOODSTOVE Type	Use	HRV?	Bath Fans	Dryer ?	Vent ?	Kitch fan?	System Type	Filter	Heat Fuel 1	Draft 1/2/3	DHW Fuel 1	Draft 1/2/3	Type	Scale? Fung?	Use?	Exist?	Use?	Cond?	Temp dif	Hrs
1	0	0	0		0	1	0	0	0		0	0	1	1	0	FWA		Gas	2	Gas	2	Usonic						0.0	
3	0	0	0.5	Not occ	0	0	0	0	0	0	0	1	1	1	1	BBD	0	Elec	3	Elec	3	Usonic	0		0	0.1		0.0	
6	1	?	0	A	0	1	1	0	0		0	A	1	1	0	FWA	G	Gas	1	Gas	1	F-Drum	0	7	0			0.0	
12	0	?	0.1	Effour	0	1	1	0	0		0	0	1	1	?	FWA	F	Gas	1	Gas	1	C-Drum	0	0	1	?	0	2.8	9
14	0	1	0.1	B	1	0	0		2	?	0	0	1	1	2	FWA	P	Gas	1	Gas	1	F-Drum	0	0	1	S	0	2.8	9
20	0	0	0		0	1	0		2	1	0	0	1	1	1	FWA		Gas	1	Gas	1	BPass	0	0	1	?	G	0.0	
32	0	0	0.1		1	0	0		2	?	0	1	1	1	1	BBD		Wood	1	Gas	1	0			1	?	Scum	0.0	?
35	0	1978	0		0	1	0		0		0	0	1	1	2	FWA	VG	Gas	1	Gas	1	F-drum	S	7	0			0.0	
43	1	0	0	C	0	1	1	0.1	1	0.2	0	0	1	1	?	FWA	P	Gas	1	Gas	1	P-Drum	SS	7	1	?	G	0.0	
56	0	1990	0	CD-90	0	0	1	0.1	1	5	0	1	1	1	2	BBD		Elec	1	Elec	3	Usonic	0	2	1	S		0.0	
76	1	1990	0	EFH	1	0	0		0		0	0	1	1	2	FWA		Wood	1	Elec	3	P-drum	S		1		G	5.6	9
84	0	0	0		1	0	0		0		0	A	1	1	1	BBD		Elec	3	Elec	3	Vaporiser		?	1		VG	2.8	7.5
86	0	1984	0		0	1	1	?	0		0	1	1	1	1	FWA	G	Gas	1	Gas	1	Usonic	0	7	0			2.8	7
95	1	0	0	GH	0	0	0		0		0	1	1	0	3	FWA	G	Gas	1	Gas	4	0			0			2.8	9
96	0	1	1	LK	0	0	0		0		0	0	1	1	2	FWA	G	Oil	1	Elec	3	none			1	S	G	0.0	
98	0	0	0	L	0	0	1	0.1	0		0	0	1	1	2	FWA	G	Gas	1	Gas	1	FDrum	FM	1	1	S	Dry	3.3	12
99	0	0	0	MN	0	1	0		0		0	1	1	1	1	FWA		Gas	3	Elec	3	none			0			1.7	8
101	0	0	0	Z	0	0	0	0	1	?	0	0	1	1	2	FWA	G	Oil	1	Elec	3	FDrum	0	0.25	0			10.0	14
108	0	0	0	P	0	1	1	0.1	1	0.1	0	1	1	1	5	FWA	E	Gas	1	Gas	1	FDrum	S	0	1	S	E	2.8	7
108	1	1	0	QC	0	1	1	0	0		0	1	1	1	4	FWA	P	Gas	3	Gas	2	FDrum	S	0	1	100	G	1.1	8
110	0	1985	0.1	D-90 Q	0	0	0		0		0	0	1	1	0	FWA	G	Gas	1	Gas	1	PDrum	0	?	1	?	G	2.2	8
114	0	1	1	LI	0	0	0		0		0	1	1	1	0	FWA	E	Elec	3	Elec	3	FDrum	S	0	1	0		3.9	16
119	0	0	0	R	0	0	0		2	5	0	1	1	1	2	FWA	E	Gas	1	Gas	1	FDrum/Uso	0	0.25	0			3.3	6.5
126	0	0	0	S	0	1	0		0		1	0	1	1	2	FWA	G	HP	3	Elec	3	Usonic		0.5	0			0.0	
127	0	1984	0	D-84	0	1	1		0		0	0	1	1	1	FWA	G	Gas	1	Gas	1	F-drum	S	1	1		Dry	0.0	
129		?	0	C	0	0	0		0		0	0	1	2	2	FWA	F	Gas	1	Elec	3	F-Drum	S	0	1	S	G	0.0	
131	1	?	0	AU	0	0	4	5	0		0	A	1	1	3	FWA	VG	Gas	1	Gas	1	Port	S		1	100	G	2.8	9
139	0	0	Washer		0	0	0		0		0	1	1	1	1	BBD		Elec	3	Elec	3	0			1	100			

lywood

ow

e installed in attic
ove grd

ks
alnted over

FPLACE/WOODSTVOE
0=none
1=exists
2=airtight
3=sealed combustion
4=Gas Sealed Comb

BATH FANS
A=vented into attic

DRYER
0=not vented
1=vented ok
2=Vented inside switchover box

KITCH FANS
0=none
1=Range Hood outside Vented
2=Recirc Raneg Hood
3=No Fan, gas range/oven
4=vented into attic
5=Range hood oside vented with Gas range

DRAFT
1= natural
2= induced
3= sealed/non combustion
4= spillage possible

Hse No.	FUNGI/MILDEW --MOULD-MILDE Cell?	Walls?	Wind?	Other?	Closets?	Sink Over Flow?	MOULDY SMELL Smell	Location	CONDENSATION Wind?	Other?	No. of Plants	Att. Green Hse?	Thermal Bridge Other	SUBJECT--IVE MOULD--INESS	AREA AND VOLUME ----Floor Areas---- Main m^2	Upper m^2	Base m^2	Gross m^2	VOLUME (m^3)	Envelope Area m^2	BLOWER DOOR AIR-TIGHTNESS Inside Temp	Outside Temp	----Measured data---- C	n
1	A	0	B,C	0	1	M	0		D	0	6	0	EF	1	61.8		56.9	136.7	361.0	336.0	19.5	10.5	80.13	0.685
3	0	0	0	0	0	0	0		A	0	6	0		0	64.0		63.9	167.9	406.0	345.3	18.3	2.0	55.11	0.671
6	0	0	B,D		0	0	1	Base	0	0	15	0		1	69.6	65.1	68.1	203.0	533.0	406.1	19.6	10.5	447.75	0.537
12	0	0	0	0	1	0	1	Drain	0	0	3	0	G	1	73.4	68.5	69.2	211.1	551.0	406.7	19.3	-12.5	73.27	0.926
14	E	0	0	F	0	0	1	Drain	A	0	3	0	H	1	91.5		91.5	183.0	473.0	401.5	21.6	-7.0	123.42	0.715
20	0	0	H	0	1	0	0		BC	0	0	0	U	1	121.0		98.5	219.5	568.0	475.9	21.0	-7.5	124.20	0.643
32	1	1	All		3	0	0		All	0	Many	0		7	93.1		74.7	167.8	439.0	376.4	19.9	3.0	91.85	0.591
35	0	0	CI	0	0	0	0		0	0	5	0	H	1	77.9		64.4	142.3	378.0	346.7	13.5	8.5	98.51	0.712
43	0	0	0		1	0	0		0	0	10	0	K,L	1	105.9	102.9	89.1	297.9	906.0	614.0	23.0	-3.0	265.22	0.710
56	0	0	J		1	0	0		J		5	0		0	97.2		100.0	197.2	497.0	414.1	21.5	1.5	121.51	0.668
78	0	0	K		2	0	1	Br/Base	K		9	0	M	2	69.3	66.8	18.7	154.8	375.0	364.4	20.0	4.0	259.57	0.607
84	1	0	GH		2		0		1		11	0	M	5	82.3		83.2	165.5	417.0	344.5	20.8	3.0	44.40	0.698
86	0	0	HI		1	0	1	Closet	F		4	0		1	97.3		99.6	196.9	507.0	396.4	21.0	-5.0	118.43	0.626
95	0	0	G		1	0	1	Base/Craw	0		6	0	N	3	124.6		37.4	162.0	394.0	434.6	19.8	-1.0	107.29	0.816
96	0	1	J		1	0	1	Base	0		7	0	Z	3	85.7		86.0	173.6	430.0	358.9	12.3	4.5	107.48	0.714
98	J	J	GL		1	0	0		CE		4	0		1	49.7	61.2	100.3	211.1	550.0	469.7	19.7	-2.0	126.97	0.667
99	M	0	M		0	0	0		G		12	0	P	0	130.5			130.5	348.0	366.6	22.0	-3.0	241.47	0.598
101	1	1	All		3	0	0		All		5	0	Q	9	105.2		111.1	216.3	536.5	417.7	17.0	-8.0	53.60	0.722
108	0	0	G	F	1	0	1	Storage	0	0	14	0		1	99.0	60.5	93.9	253.4	662.0	506.6	21.0	9.0	155.54	0.702
108	0	0	U	N	0	0	1	Garage	0	0	2	0		1	90.0		80.2	170.1	436.0	382.7	20.0	8.0	73.72	0.665
110	0	0	0	M	1	SS	1	Sump	0	0	9	1		1	83.7		93.9	177.6	449.0	371.3	21.5	-2.0	95.79	0.672
114	0	0	O		2	0	1	Base/CI	A		5	0	Z	3	86.7	61.1	78.0	225.8	605.0	433.0	19.5	0.0	113.65	0.604
119	0	0	BGO		1	0	0		AC		0	0	R	1	65.4	62.7	54.2	202.3	527.0	453.4	22.0	0.0	93.27	0.746
126	0	0	0	P	1	0	0		0	0	6	0	S	1	173.8		166.5	362.3	936.8	694.7	20.3	2.7	72.76	0.766
127	0	0	0	0	1	0	0		0		5	0		0	84.9	70.3	62.7	217.9	544.0	434.5	21.4	-7.0	427.81	0.630
129	0	0	O	S	1	0	0		0	L	5	0		2	71.4		64.2	135.6	326.0	300.1	22.5	8.5	111.94	0.676
131	0	1	HI	R	1	0	1	Base	F		15	0		2	107.5		72.0	179.5	463.0	423.0	21.5	-4.0	87.83	0.716
139	A	A	OL		2	0	0		AE		6	0		3	81.3		81.3	162.7	412.0	342.5	23.0	-3.0	33.18	0.750

CLOSETS

1 O/s wall, no mould
2 O/s wall, smell only
3 O/s wall, mouldy

CONDENSATION

A Between panes
B Mbr Windows
C Bathroom Windows
D Basement windows
E Living Room Windows
F Br Windows
G Marks, dry now
H Mbr Windows
I Child's Bdr
J Trace ony, Dry @ visit
K Single glazed Windows
L Inside Storm Door

FUNGI/MILDEW

A Upper corner MBR
B Upper Level Windows
C Basement windows
D Windows with draperies
E Cell over Bathtub
F Bathtub Surround
G Bathroom Windows
H Mbr Windows
I Child's Bdr
J Trace ony, Dry @ visit
K Single glazed Windows only
L Living room windows
M Previous Marks ,Dry now
N Howner sez mould/moisture problem after inst. Pulse, "fixed" when old flue re-opened
M Basement wall, @ leak site
O Between Panes
P Dirt/Mould in HRV F/A
Q Pet Cockatiel
R Basement Walls

OTHER-THERMAL BRIDGES

E Hair dress rm adj., perms about 1ce/week
F Hobby painting using acrylic paints
G Cockatiel, Loose often in l/r
H opening to R/A in Furn Room (closed during visit)
I Condens/Mould on Br windows directly related to vaporiser use, windows recently replaced
J Kitchen under renov at time of visit
K Sunporch attached,leaks
L Hot Tub in Basement
M Kerosene heater
N Unvented/Backspilling Gas Appliances
Z Mouldy Const Mat'ls in Base active leaks wetting
P Bad Moisture prob. solved by changing Elec basebd to Gas furn in attic w/o/a intake
Q @ visit #2, TBridges:
10C-Bdrm lower Wind Corner
8C-Base ext corner
6C-Base Sg Wind Lwr corner
R Woodstove backpuffs Chimney too short

Hse No.	Corr.	Calculated data: cm^2 ELA10	cm^2/m NLA10	Q50 l/s	ACH50	Q-Predicted: l/s	ACH	PFT INFILTRATION: AIR CHANGE per hr	AIR CHANGE l/s	Standard Deviation	Start Time	Start Date	Stop Time	Stop Date
1	0.999	696	2.06	511	5.1	30	0.30	0.207	21	0.033	14.45	Mar-26	16.16	Apr-8
3	0.997	486	1.41	359	3.19	21	0.19	0.166	19	0.045	9.00	Jan-16	12.25	Jan-21
6	0.995	2689	7.14	1726	11.66	127	0.86	0.726	108	0.206	16.27	Mar-26	12.10	Apr-8
12	0.989	1166	2.87	1307	8.54	96	0.63	0.701	107	0.236	10.30	Jan-22	17.45	Jan-29
14	0.997	1206	3.00	956	7.29	56	0.43	0.562	74	0.167	15.45	Jan-22	14.30	Jan-28
20	0.972	1027	2.16	725	4.59	43	0.27	0.479	76	0.175	19.15	Jan-22	18.20	Jan-29
32	0.996	674	1.76	438	3.59	26	0.21	0.261	34	0.048	18.25	Feb-5	15.25	Feb-12
35	0.996	955	2.75	754	7.18	44	0.42	0.255	27	0.157	15.45	Mar-19	12.35	Apr-8
43	0.989	2750	4.48	2184	8.59	159	0.63	0.564	142	0.187	17.00	Feb-12	17.45	Feb-26
56	0.996	1066	2.57	785	5.66	46	0.33	0.426	59	0.107	12.25	Feb-15	12.00	Feb-21
76	0.992	1975	5.42	1316	12.64	97	0.93	0.567	61	0.186	18.40	Feb-19	18.00	Mar-19
84	0.984	417	1.21	322	2.78	19	0.16	0.161	19	0.039	7.30	Mar-19	10.43	Apr-9
86	0.996	947	2.39	654	4.64	38	0.27	0.293	41	0.051	13.45	Feb-12	18.30	Feb-26
95	0.995	1323	3.04	1236	11.3	61	0.74	0.659	72	0.262	15.50	Jan-29	15.40	Feb-5
96	0.989	1046	2.91	828	6.93	49	0.41	0.310	37	0.131	10.44	Mar-19	10.35	Apr-8
98	0.996	1110	2.36	815	5.33	53	0.35	0.366	59	0.095	11.10	Feb-26	12.45	Mar-18
99	0.997	1606	4.67	1189	12.27	70	0.72	0.326	32	0.087	19.45	Feb-12	16.45	Feb-19
101	0.990	532	1.27	427	2.66	25	0.17	0.101	15	0.012	19.45	Feb-26	18.20	Apr-8
106	0.996	1473	2.91	1143	6.22	75	0.41	0.483	89	0.204	11.20	Mar-27	11.32	Apr-8
108	0.966	642	1.66	470	3.66	26	0.23	0.229	26	0.057	20.24	Mar-26	19.04	Apr-8
110	0.996	846	2.26	626	5.03	37	0.30	0.306	36	0.04	11.10	Jan-29	14.05	Feb-11
114	0.994	1362	3.15	1247	7.42	92	0.55	0.448	75	0.156	18.00	Mar-12	17.25	Apr-8
119	0.997	979	2.16	817	5.56	60	0.41	0.440	64	0.064	13.20	Jan-29	15.20	Feb-4
126	0.996	799	1.15	668	2.64	40	0.16	0.226	59	0.054	11.50	Feb-5	15.40	Feb-11
127	0.976	3437	7.91	2360	15.76	175	1.16	1.063	161	0.246	14.15	Jan-22	10.15	Jan-29
129	0.995	999	3.33	744	8.17	44	0.48	0.303	28	0.081	13.55	Feb-19	17.05	Mar-18
131	0.996	860	2.03	664	5.32	40	0.31	0.401	52	0.066	13.45	Feb-26	13.33	Mar-18
139	0.997	351	1.03	295	2.57	17	0.15	0.189	22	0.04	19.10	Mar-12	19.42	Apr-8

Hse No.	MICROBIOLOGICAL AIR SAMPLES: Outside FCFU	Kitchen FCFU	Kitchen MType	Kitchen I/O	Kitchen Bact	Living FCFU	Living MType	Living I/O	Living Bact	Base FCFU	Base MType
1	200	347	9	2	n/a	88	5	0	n/a	236	8
3	22	78	8	4	344	44	5	2	422	56	4
6	131	253	7	2	n/a	200	8	2	n/a	515	9
12	37	6	1	0	1047	31	2	1	119	131	5
14	37	125	4	3	1159	100	3	3	906	19	3
20	37	13	2	0	267	25	3	1	334	63	3
32	91	297	8	3	n/a	453	10	5	n/a	1531	12
35	416	56	3	0	1172	50	4	0	1203	203	8
43	50	106	6	2	494	3	1	0	106	344	10
56	22	22	3	1	668	34		2	975	181	10
76	388	169	7	0	3906	109	5	0	1375	294	8
84	126	103	5	1	3166	88	5	1	2438	119	5
86	31	59	5	2	609	69	5	2	900	163	6
95	28	206	13	7	730	109	4	4	409	4630	12
96	138	47	4	0	813	50	3	0	844	253	8
98	186	81	6	0	828	88	5	0	838	406	10
99	31	6	1	0	206	16	4	1	297	109	6
101	106	331	10	3	1391	950	10	9	1686	586	12
106	200	44	3	0	n/a	22	2	0	n/a	109	7
108	200	88	5	0	219	75	5	0	594	281	7
110	28	109	5	4	222	53	4	2	256	72	5
114	41	566	8	14	1213	284	10	7	1094	1281	10
119	28	25	3	1	572	47	3	2	191	225	8
126	91	181	8	2	n/a	128	6	1	n/a	531	12
127	37	19	3	1	750	6	1	0	513	100	5
129	169	69	4	0	244	66	4	0	181	281	8
131	31	306	5	10	269	100	5	3	144	781	10
139	109	200	5	2	713	219	5	2	594	391	6

Note:
Q Predicted = Q50/17 for single stories
Q Predicted = Q50/15.3 for 1.5-stories
Q Predicted = Q50/13.6 for 2-stories

FCFU= Fungal Colony Forming Units/m^3
Bact= Bacterial Colony Forming Units/m^3
MTyp Number of Fungal Colony Morphot
I/O= Indoor-Outdoor FCFU ratio

FUNGAL SPECIES CODES

ACA	Acremonium alternatum	PCH	Penicillium chrysogenum
ALA	Alternaria alternata	PDE	Penicillium decumbens
ACN	Aspergillus candidus	PFU	Penicillium funiculosum
ACL	Aspergillus clavatus	PHE	Penicillium herquei
ANI	Aspergillus niger		
AOR	Aspergillus ornatus	PNI	Penicillium nigricans
ATE	Aspergillus terreus	PPU	Penicillium purpurogenum
AUP	Aureobasidium pullulans	PRE	Penicillium restrictum
CLC	Cladosporium cladosporoides	PRU	Penicillium rugulosum
CLH	Cladosporium herbarum	PHS	Phoma sp.
CRA	Cryptococcus albidis	RHS	Rhizopus sp.
DRD	Drechslera dematioidea	RHG	Rhodotorula glutinis
FUA	Fusarium aqueductum	RHM	Rhodotorula minuta
PBR	Penicillium brevicompactum	RHR	Rhodotorula rubra
PCA	Penicillium camemberti	STB	Stemphillium botryosum

Hse ment--- No.	I/O	Bact	-Predominant- Fungal Species Code	Loc	--Predominant-- Bact. Species Code	Loc	MICROBIOLOGICAL SURFACE SAMPLES ---Surface Sample # Location	Code	BCount	FCount	---Surface Sample # Location	Code	BCount	FCount	MICROBIOLOGICAL SURFACE SAMPLES, cont'd ---Surface Sample # Location	Code	BCount	FCount	-Predominant- Bact. Species Code	Loc	-Predominant- Fungal Species Code	Loc
1	1	n/a	PPU	K	n/a	n/a	K-sink beh	KS	44,000,000	4	Mbr Wind	WM	7,500	3	Base wind	WBA	140,000	3	FLS	?	AUP	KS
3	3	356	ALA	K	SHA	L	Bsmnt Win	BW	1,600,000	1	Kitch Wind	WK	750,000	3	Ref Conde	RCT	1,200,000	1	BME	BW	ACA	WK
6	4	n/a	CLH	B	n/a	n/a	Child-BR	WC	100,000	3	Attic Wd b	AW	75,000	0	Tub-surrou	BAS	3,000,000	3	KLO	BAS	AUP	WC
12	4	491	CLH	B	RHS	K	Flr Drain L	FD	3,200,000	3	Humidifier	HP	86,000	1	Ref Conde	RCT	1,000,000	1	COX	FD	ACA	FD
14	1	286	RHR	K	MIL	K	Flr Drain B	FD	1,600,000	3	Furnace Fl	FF	8,100	2	Tub Surro	BAS	1,700,000	3	MES	BAS	ATE	FD
20	2	203	ALA	B	SWA	L	Ref Cond t	RCT	770,000	2	Ens Windo	WB	1,200,000	1	Flr Drain L	FD	280	0	PSA	WB	PHS	FD
32	17	n/a	PHE,PRU	L/B	n/a	n/a	Mbr Wind	WM	n/a	3	Closet-Hd	CWC	n/a	3	Ref Conde	RCT	n/a	1		?	AOR	CWC
35	0	958	CLC	B	MIL	L	Child(Rear	WC	25,000	2	Ref tray (dr	RCTD	0	0	Shower flo	BAS	1,500,000	3	BCI	BAS	CLC	BAS
43	7	516	CLC	B	SHA	L	Humid Pa	HP	2,000,000	3	Furnace Fl	FF	800	0	Ref Conde	RCT	20	4	CLM	HP	CLH	RCT
56	8	444	ALA	B	MIL	L	Bath Tub	BAS	8,000	3	Ref Conde	RCT	4,100	2	Mbr Windo	WM	17,500,000	3	ACI	WM	DRD	BAS
76	1	1046	CLH	K	SSA	K	H20 pipes	WP	200	0	Win-sg wo	WO	90,000,000	3	Sump pum	SH	40,000,000	3	PSF	WO	RHG	SH
84	1	2531	ACL	B	SSA	K	Mbr Windo	WM	1,000,000	2	Bsmnt Flr	FD	200,000,000	2	Oside Clo	CW	5,000,000	3	PSF	FD	PBR	CW
86	5	475	CLH	L	SHA	L	Mbr Windo	WM	2,000,000	3	furnace Fil	FF	800	0	Ref Gasket	RG	20	4	CLM	WM	CLH	RG
95	165	1953	AUP	B	SXY	B	Cld rm Flr,	CRF	73,000,000	4	Bath tub s	BAS	720,000,000	4	Mbr Windo	WM	800,000	3	MIL	BAS	CLC	BAS
96	2	140	PNI	B	SXY	?	Bsmnt SE	BW	10,000,000	0	Bot of Bar	BWF	120,000,000	0	Pet Food	PF	20,000	3	PSF	BWF	STB	PF
98	2	619	PFU	B	COS	K	Lwr Bath	WB	400,000	3	Humidifier	HP	300	0	laundry Wi	WL	21,000,000	4	AUS	WL	RHR	WL
99	4	353	CLH	B	SWA	L	ref Conde	RCT	200,000	1	Ens Windo	WB	12,000	2	Mbr Windo	WM	170	2	BCI	RCT	CLH	WB
101	5	975	PRE	L	ARO	L	Base Wind	WBA	2,500,000	3	Humidifier	HP	130,000	0	Ref Conde	RCT	2,500,000	3	PSF	WBA	FUA	RCT
106	1	n/a	PRU	B	n/a	n/a	Ensuite Wi	WB	700,000	2	Main Bath	WB	40000	3	E-Child B	WC	2,000,000	3	COS	WC	CLH	WC
108	1	563	PCH	B	SCO	L	Cold Roo	CRC	1,000,000	3	Child Br W	WC	20,000	1	Furnace Fl	FF	1,000	2	ACG	CRC	CLH	CRC
110	3	344	PCA	K	SHA	B	Humidifier	HP	60,000	0	faucet-K-si	KS	117,260	3	Sump hole	SH	20,000,000	3	AUS	KS	ACA	SH
114	31	2875	ATE	?	BCE	B	Bsmnt Ed	BWF	5,000	0	bsmnt Edg	BWF	500,000	3	Basement	BS	1,500,000	2	BCE	BS	PDE	BWF
119	8	884	ANI	B	MIL	K	Humidifier	HP	120,000,000	0	ref Conde	RCT	125,000,000	2	Floor Drain	FD	125,000,000	3	BME	RCT	CLH	FD
126	6	n/a	RHS,PCH	B	n/a	n/a	Sump Wat	SHW	n/a	3	HRV F/A P	HRP	n/a	3	HRV under	HRP	n/a	3		?	CRA	HRP
127	3	228	PRE	B	SWA	K	Humidifier	HP	46,000	1	Dehumidif	DHP	210,000	2	Ref Conde	RCT	350,000	1	BCI	HP	CLC	DHP
129	2	772	RHS	B	ACG	B	Range hoo	RHF	2,000	1	Rfe conde	RCT	30,000,000	2	Bsmnt leak	BF	6,400,000	0	ALP	BF	CLC	RCT
131	25	1266	AOR	B	BSP	B	Bsmnt Bdr	BW	94,000,000	4	Humidifier	HP	68,000,000	3	Ret Air Gril	RAG	50,000	2	PSV	BW	CLH	BW
139	4	913	STB	B	SWA	B	Mbr Upper	CWM	200,000	3	LR wind sil	WO	8,500,000	2	Bath wind	WB	18,000,000	3	BME	WB	CLH	WB

ypes

K=Kitchen
L=Living area
B=Basement

BACTERIUM SPECIES CODES

ACG	Acinetobacter geno sp.9	MES	Methylobacterium sp
ACI	Acinetobacter lwoffi	MIL	Micrococcus luteus
ALP	Alcaligenes paradoxus	PSA	Pseudomonas aureof
ARO	Arthrobacter oxydans	PSF	Pseudomonas fluore
AUS	Aureobacterium sp.	PSV	Pseudomonas vesicu
BCE	Bacillus cereus	RHS	Rhodococcus sp.
BCI	Bacillus circulans	SCO	Staph-cohnii
BME	Bacillus megaterium	SHA	Staph. haemolyticus
BSP	Bacillus sphericus	SSA	Staph. saprophyticus
CLM	Clavibacterium michiganense	SWA	Staph. warneri
COS	Corynebacterium sp. (Gp.ANF1)	SXY	Staph. xylosus
COX	Corynebacterium xerosis		
FLS	Flavobacterium sp.		
KLO	Klebsiella oxytoca		

LOCATION CODES

AW	Attic Wood
BAS	Bath (tub/shower) Surround
BF	Basement Floor
BS	Basement Soil
BW	Basement Exterior Wall
BWF	Basement Wall/Floor
CRC	Cold Room Ceiling
CRF	Cold Room Floor
CW	Closet Wall
CWC	Closet Wall/Ceiling
CWM	Ceiling/Wall Master Bedroom
DHP	Dehumidifier Pan
FD	Floor Drain
FF	Furnace Filter
HP	Humidifier Pan
HRP	Heat Recovery Ventilator Pan
KS	Kitchen Sink (behind taps)
PF	Pet Food
RAG	Return Air Grille
RCT	Refrigerator Condensate Tray
RCTD	Refridgerator Condensate Tray, Dry
RG	RG Refridgerator Gasket
RHF	Range Hood Filter
SH	Sump Hole (not water)
SHW	Sump Hole Water
WB	Window, Bathroom
WBA	Window, Basement
WC	Window, Child's Bedroom
WK	Window, Kitchen
WL	Window, Laundry
WO	Window, Other
WP	water Pipe

FCount

0	No Colonies
1	A few colonies on undiluted sample
2	Moderate numbers on the undiluted sample and a few on the 1/100 dilution
3	Moderate numbers on the 1/100 sample and a few on the 1/10,000 dilution
4	Moderate numbers on the 1/10,000 sample

MYCOLOGIST'S REPORT

REPORT ON SAMPLES FROM OLDER HOMES FOR MICROBIOLOGICAL POLLUTANTS January - March 1991

James L. Whitby

Results

A summary of the results obtained is contained in the main Table which records and bacterial and fungal air counts for each house in which these samples were taken
and the predominant bacterial and fungal species isolated and the site from which that isolate came. Usually, that was from the strip with the highest overall count but there were a few occasions in which one colonial morphotype on a strip with a lower total count was actually more numerous. The sample from which the identified species was taken is indicated by an asterisk. Similarly, the swab results are reported and the predominant species identified.

Analysis of the predominant species isolated shows some expected results.

The predominant bacterial species selected from the air sample strips were almost exclusively Gram-positive; only two Gram-negative species were represented, Rhodococcus and Acinetobacter. Of the Gram-positive organisms, Micrococcus luteus was the most frequent selection occurring in five houses, but in 12 houses, Staphylococcus sp. were the predominant species with the number of houses in brackets: S. haemolyticus (3), S. Saprophyticus (2), S. xylosus (2) and S. cohnii (1). None of these are actively pathogenic human species. The other isolates, one house each, were Bacillus cereus, Bacillus sphaericus, Corynebacterium gp. ANF1, Rhodococcus and Arthrobacter oxydans.

From the environmental samples, Gram-negative bacteria were, more frequently, found to be the predominant isolate but this would not be unexpected from moist sites or liquids, and the non-standardized nature of the sampling procedure meant that liquid samples were not submitted from all houses. Pseudomonas from moist sites and Bacillus sp. from dry sites predominated. The

listing of predominant bacterial species now follows: Pseudomonas fluorescens (5), P. aureofasciens (1), P. vesicularis (1), Bacillus megaterium (3), B. circulans (3), B. cereus (1), Aureobacterium sp. (2), Corynebacterium sp. (1), C. xerosis (1), Acinetobacter Iwoffi (1), Flavobacterium sp. (1), Micrococcus luteus (1), Methylobacterium sp. (1), Clavibacterium michiganense (1), Alcaligenes paradoxus (1) and Klebsiella oxytoca (1).

The predominant fungal species isolated from each set of environmental swabs and each set of air samples are listed in Table 1.

Some 30 different fungi were isolated, of which the two species of Cladosporium herbarum and cladosporoides were the commonest.

Overall, the commonest fungi genera isolated were Cladosporium sp. 18 (27.8%), Penicillium sp. 14 (22.9%), Aspergillus sp. 7 (11.5%), Aureobasidium sp. 4 (6.6%) and Alternaria sp. 3 (5.0%). Penicillium was the commonest species isolated from air (11 of 31 isolates or 35.5%) and Cladosporium was the commonest species from the environmental samples (11 of 30 isolates or 36.7%).

Table 1. Fungal Species Isolated from Older Homes

Species	Number of Isolates		
	Total	From Air	From Swabs
Acremonium alternatum	2	0	2
Alternaria alternata	3	3	0
Aspergillus candidus	1	0	1
Aspergillus clavatus	1	1	0
Aspergillus niger	1	1	0
Aspergillus ornatus	2	1	1
Aspergillus terreus	2	1	1
Aureobasidium pullulans	4	1	3
Cladosporium cladosporoides	6	2	4
Cladosporium herbarum	12	5	7
Cryptococcus albidis	1	0	1
Drechslera dematioidea	1	0	1
Fusarium aqueductum	1	0	1
Penicillium brevicompactum	1	0	1
Penicillium camemberti	1	1	0
Penicillium chrysogenum	2	2	0
Penicillium decumbens	1	0	1
Penicillium funiculosum	1	1	0
Penicillium herquei	1	1	0
Penicillium nigricans	1	1	0
Penicillium purpurogenum	2	1	1
Penicillium restrictum	2	2	0
Penicillium rugulosum	2	2	0
Phoma sp.	1	0	1
Rhizopus sp.	2	2	0
Rhodotorula glutinis	1	0	1
Rhodotorula minuta	1	1	0
Rhodotorula rubra	3	1	2
Stemphilium botryosum	2	1	1

Taking the counts overall, there is a wide fluctuation and even analysis made by comparing the figures from each separate area in the house rather than averaging them all together, displays the same wide fluctuation.

Table 2

Agent	Site	N	Mean Count/1000 L Air	Standard Deviation
Bacteria	All Rooms	69	817.9	741.7
Bacteria	Site 1	23	709.5	571.2
Bacteria	Site 2	23	910.7	913.4
Bacteria	Site 3	23	833.6	721.9
Fungi	All Rooms	87	249.0	536.3
Fungi	Site 1	29	127.4	177.2
Fungi	Site 2	29	157.2	156.7
Fungi	Site 3	29	482.8	855.1
Fungi	Outside Air	20	114.0	115.0

Predominant fungal species and bacterial species, where bacterial air samples were taken, found in the houses with the highest fungal counts, are listed in Table 3:

Table 3
Predominant Species in Houses with the Highest Aerial Counts

House #	Bacteria	Fungus
76	Staph. saprophyticus	Cladosporium herbarum
84	Staph. saprophyticus	Aspergillus clavatus
95	Staph. xylosus	Aureobasidium pullulans
101	Arthrobacter oxydans	Penicillium restrictum
114	Bacillus cereus	Aspergillus terreus
1	Not sampled	Penicillium purpurogenum
6	Not sampled	Cladosporium herbarum
32	Not sampled	Penicillium rugulosum & herquei
43	Micrococcus luteus	Cladosporium cladosporoides
126	Not sampled	Rhizopus sp. & Penicillium chrysogenum
131	Bacillus sphaericus	Aspergillus ornatus
139	Staph. warneri	Stemphilium botryosum

This, again, does not show any pattern that can be readily analyzed without reviewing all the data.

Pathogenicity of Fungal Isolates

None of the fungi isolated are species that are regularly associated with clinical syndromes in the human race. They are not causative agents of the deep-seated mycoses nor of the dermatophytic infections, nor are they commonly associated with opportunistic infections. However, many species of fungi have occasionally been associated with human infection, especially in patients with illness involving the immune system or leukocyte function, such as HIV or leukemia or with chronic cavitating lung disease such as tuberculosis or bronchiectasis.

Among fungal genera causing such opportunist infections are to be found Acremonium, Alternaria, Aspergillus, Cladosporium, Drechslera, Penicillium, Rhizopus and Rhodotorula; of these, the following species reported as predominant in samples from houses in Tillsonburg, have been documented in human disease: Aspergillus clavatus, A. niger, A. ornatus and A. terreus; Rhizopus and Rhodotorula rubra. Although the Aspergillus species found have been associated with human disease, particularly Aspergillus niger, the Aspergillus species that is most commonly associated with human disease, Aspergillus fumigatus, was not found as the predominant organism in any sample. That does not mean that the samples did not contain this organism, as the commonest isolate was the only one speciated.

From the point of view of human health, the presence of large numbers of fungal spores in the air would be more likely to be associated with hypersensitivity problems. Species found to be important in Farmer's lung, where exposure is many times larger than likely to be encountered inside old homes in Tillsonburg, have largely been many different species among the genera Aspergillus and Penicillium. Aspergillus and Penicillium were certainly common in the Tillsonburg samples are were expected to be, as they are common aerial contaminants.

Comment

When this study had been underway for one month, a protocol was received suggesting that a rather more detailed examination be made than had initially been proposed. This request was not

complied with because the additional work had not been budgeted for, particularly for the necessary time for the further work. Some fungal samples were examined with lactophenol/cotton blue mounts. One general comment could be made. Cladosporium sp., Penicillium sp., Aspergillus sp. and Alternaria sp. were present on all such samples examined. Aureobasidium, however, seemed either to be present in large numbers or, if present, be in only very small numbers.

In an investigation such as this one, it is hard to decide in advance what would be the best sampling conditions. On the basis of experience in this institution (University Hospital, London, Canada) of bacterial air counts and on pilot samples submitted by Mr. Bowser, an 8 minute sampling time was chosen. For most of the houses sampled, 8 minutes were appropriate because the number of colonies observed could be accurately enumerated. However, counts >1,000/cubic metre would have been more accurately enumerated with a 4 minute or 2 minute sampling time. In particular, with high counts, the slow-growing species will be obscured by the number of colonies of rapid growers. Usually with high counts, the counting procedure had to be terminated before the designated counting period had elapsed in order to make a subculture of the predominant species.

Perhaps really in this preliminary study, all that would have been realistic to observe would have been the level of aerial contamination with bacterial and fungal colony-forming units and, after review of data, to return to selected houses for a more detailed evaluation and speciation of the contaminants present. However, from the number of bacterial and fungal morphotypes on aerial samples, it would be a prodigious task even to identify to species all the microbial species present on three bacterial and three fungal air samples from a single house.

SLIDES

1. Humidifiers

12-6 Portable drum-type humidifier

43-35 Portable drum-type humidifier, has cloudy water, high bacterial and fungal counts.

20-9
20-8 Mould growth on ensuite window attributable to operation of portable humidifier in master bedroom.

101-25 Humidifier (furnace mount) with cloudy water, no fungi, low bacteria count.

98-17 Furnace humidifier pan apparent colonies; sample analysis shows no fungi and low bacterium.

2. Closets

32-25 Mould growth in closet on outside wall.

101-13 Mould on attic hatch (in closet).

3. Windows

101-22 Mould and condensation on single glazed basement window.

101-17 mould on window, severe.

101-22A Mould and condensation on patio door, aggravated by heavy drapes.

6-3 Heavy curtains in front of window.
6-4 Leads to condensation and mould growth on window

4. Refrigerator Drain Pans

101-3 Refrigerator drain pan.

76-36 Refrigerator drain pan with cloudy water. This kitchen had high bacterial counts, Drain pan not sampled.

126-11 Mould in refrigerator drain pan.

129-4 Refrigerator drain pan. predominant fungal species is Cladosporium cladosporoides, activity level 2.

Bacterium count was 30,000,000 colonies/ml, unspeciated.

131-7 Refrigerator pan has condenser loop under drain pan. Pan is heated, water evaporates quickly, no microbiological activity.

5. Walls/Ceilings

101-7 Mould marks at ceiling.

101-19 Mould on basement wall, cold corner.

6. Basements

56-16 Perimeter drainage has recently been improved.

96-40 Wet construction materials from flooding and active water leakage.

108-18 Moisture and fungal activity in "cold-room". High fungal activity, medium bacterial. Fungal species is Acinetobacter sp.

114-36 Wood plank/soil floor. Bacterium isolated is Bacillus cereus, also identified as predominant in basement air sample with high counts (2875 cfu/m^3).

95-18 Crawlspace with exposed soil. Highest recorded fungal air count of 4630 cfu/m^3. Predominant fungus in air is Aureobasidium pullulans. Also high bacterium (1953 cfu/m^3), predominant species Staph. xylosus.

95-19 Concrete block foundation with heavy efflorescence/water evaporation.

131-15 Poor drainage, grade slopes back towards foundation. Foundation is not water-resistant. Recorded fungal air count of 781 cfu/m^3 (I/O ratio 25) in this basement, Predominant fungal species are Aspergillus ornatus in air, Cladosporium herbarum isolated from basement wall on the inside at activity level 4.

Bacillus sphericus predominant bacterial species in basement air (1266 cfu/m^3), Pseudomonas vesicularis from basement wall at concentration of 94,000,000 colonies/ml.

7. Exterior

129-14 Mould on underside of carport.

95-17 Bath-fan vents into carport; mouldy siding.

8. Miscellaneous

6-20 Active wood fungi in attic.

126-7 Mould in HRV fresh air drain pan. Sample showed higher fungal activity with Cryptococcus albidis var. albi as predominant species.

95-7 Mouldy siding and improper combustion vent.
95-20 Gas-fired natural draft hot water heater with signs of periodic back-spillage.

14-6 Furnace has opening into return air close to furnace.